ANNALS
OF
The Entomological Society of America

Volume XXI JUNE, 1928 Number 2

THE BIOLOGICAL CONTROL FACTORS OF THE IMMATURE STAGES OF EUXOA OCHROGASTER GN. (LEPIDOPTERA, PHALAENIDAE) IN SASKATCHEWAN.*

KENNETH M. KING AND N. J. ATKINSON,
Dominion Entomological Laboratory, Saskatoon, Sask.

INTRODUCTION.

In approaching an economic problem from the ecological viewpoint, as is so often necessary in investigations of insect pests, a study of the part played by natural control factors is generally of great practical importance as well as of scientific interest. A knowledge of the factors involved and their mode of operation explains the fluctuations in numbers of the pest and should eventually provide a means of anticipating developments. These considerations give a dual bearing to the study of the more important biotic factors affecting the principal cutworm of Saskatchewan, the red-backed cutworm (*Euxoa ochrogaster* Gn.). The data presented in this preliminary report have been accumulated during the four years 1923 to 1926 and, while the details relate in the main to conditions at Saskatoon, the principles brought out apply throughout the province of Saskatchewan.

GENERAL CONSIDERATION.

The biology of *E. ochrogaster* in the Prairie Provinces has been described in considerable detail by King ('26). The species has but a single generation per year, and hibernates in

*Contribution from the Division of Field Crop and Garden Insects, Entomological Branch, Canada Department of Agriculture.

the egg stage. The larvæ are present from the first extended warm spell in spring until about June 26th, during which time they pass through six instars. Pupation takes place in the soil. The moths are common for several weeks beginning soon after the middle of July, but oviposition does not begin until early in August. The eggs are laid in loose soil. The larvæ also spend most of their lives there though usually come to the surface at night in search of food. The red-backed cutworm is a native species now associated almost exclusively with cultivated fields.

Rather widespread outbreaks of greater or less severity have occurred ('26) in this province at intervals of from four to six years. The most recent reached its climax in 1925. At Saskatoon the species was relatively scarce in 1923 though probably more plentiful than during the preceding year. In 1924 it was nearly twice as abundant as in 1923. The damage, also, was greatly increased and the larval mortality was decreased by a phenomenally dry summer. As a result of the latter, combined with exceptionally favourable weather in the fall, the larvæ were fully ten times as plentiful in the spring of 1925 as in the previous year but a very high death rate in June 1925, combined with factors affecting the moths, reduced the numbers of the species in 1926 to about one-fifth of those of the previous season. In 1927 the species was in about the same numbers as in 1923.

The estimates of larval abundance given above are of numbers of larvæ entering the fourth instar. The difficulty of finding sufficient eggs or small larvæ under natural conditions prevents the presentation of an estimate of the abundance of these stages. The present paper is therefore concerned mainly with the mortality occurring between the beginning of the fourth instar and moth emergence. All the observations indicate that the greatest variation from year to year in the mortality of the immature stages occurs during this period. Furthermore, these observations, preliminary laboratory experiments, a study of the records of the previous outbreaks and of the associate meteorological data also indicate that, for the immature stages of this species, biological control factors are of far greater importance in reducing outbreaks than direct physical factors. In the present discussion the physical factors are treated only in their relation to the biological.

BIOTIC NATURAL CONTROL FACTORS.

The biotic natural control factors may be divided into three groups, predators, which are mainly insects, insect parasites, and diseases. Data on predators were secured from field observations and are not strictly quantitative. Data on the percentages of insect parasitism and of diseases were secured by comparative collections of larvæ from the field during the several seasons. These collections were made and the larvæ reared in the manner already described ('27), so that the results are representative and comparable. The results presented below and the conclusions drawn, while incomplete, explain to a large extent the observed fluctuations in the abundance of the species and in the prevalence of its parasites and diseases during the past four years.

PREDATORS.

Undoubtedly the larvæ and adults of many of our common carabids are predators on the larvæ of *E. ochrogaster*, perhaps also accounting for a considerable number of eggs, although definite observations have been secured only with respect to two species. Larvæ of *Calosoma calidum* Fab., have occasionally been taken feeding on nearly full-grown red-backed cutworms. Adults of a small carabid *Bembidion fusicrum* Mots., were very plentiful in the spring of 1926 in association with young *E. ochrogaster* larvæ in an alfalfa patch and a few were seen feeding on these young larvæ.

The larvæ of a therevid, *Psilocephala munda* Loew., have been taken several times in the field feeding on newly dead, well grown *E. ochrogaster* larvæ, on which they are probably true predators, although we have been unable to induce them to kill larvæ in the laboratory.

A small brown ant *Lasius niger* L. var. *neogniger* Emery* in 1926 consumed many eggs which had been put out for experimental purposes; the same species was seen to attack nearly full grown larvæ.

The Franklin gulls (*Larus franklini* Rich.) often follow a plow or cultivator in great numbers and devour many insects, including red-backed cutworms. Other birds account for a few larvæ but the number is relatively small.

*Determined by Dr. W. M. Wheeler.

The known predators are incidental enemies of this cutworm. Their importance, though appreciable, is very indefinitely known. Probably their effect is greatest on the young larvæ, the stage least easily studied. They also dispose of at least a small number of eggs.

INSECT PARASITES.

The immature stages of *E. ochrogaster* support a varied parasitic fauna. The fifteen species listed below are those reared during the four years 1923 to 1926 from larvæ or pupæ collected in Saskatchewan.

*Parasites of E. ochrogaster in Saskatchewan.**

Diptera	Bombyliidæ	*Villa halcyon* Say.
		Villa willistoni Coq.
		Villa lateralis Say.
		Villa fulviana Say.
	Tachinidæ	†*Gonia aldrichi* Toth.
		Gonia fusicollis Toth.
		Gonia sp.
		Bonnetia comta Fall.
		Phorichaeta sequax Will.
Hymenoptera	Vipionidæ	*Apanteles acronyctæ* Ashn.
	Braconidæ	†*Meteorus vulgaris* Cress.
	Ichneumonidæ	†*Sagaritis atkinsoni* Vier.
		Pansicus sp.
		Erigorgus sp.
	Encyrtidæ	†*Berecynthus bakeri* var. *gamma* Gir.

We have reared no specimens belonging to the Ichneumonid genus *Amblyteles* from Saskatchewan material of *E. ochrogaster*, although Strickland ('23) records *A. subfuscus* Cress. as an important parasite of this cutworm at Lethbridge, Alta., in 1916 and 1919, and Whitehouse ('21) reports a heavy paratism by *A. suturalis* Say. in Alberta in 1919.

A. MAJOR PARASITES.

Four species of parasites, as noted in the above list, have been of major importance. In Table I are presented estimates of the parasitism by these four species for the three years 1924

*The determinations of Diptera were made by Mr. C. H. Curran, of the Entomological Branch, Ottawa; those of Hymenoptera by Mr. H. L. Viereck, while with the same organization, and by Mr. G. S. Walley, also of this Branch.

†Species of major importance.

to 1926. These figures represent the estimates of final effective parasitism as it would have occurred under field conditions without the intervention of disease. They approximate the final results under field conditions only for 1924. In the other two years, diseases caused a heavy mortality among the larvæ in the field, materially affecting the ratios of effective parastism, as explained later. Data for 1923 are too incomplete to permit the presentation of any figures for that year.

TABLE I.

Estimated Parasitism of *E. ochrogaster* at Saskatoon.
(See text).

	1924 %	1925 %	1926 %
Gonia (all species	12	9	7
Meteorus vulgaris	4	30	6
Sagaritis atkinsoni	8	7	22
Berecynthus bakeri	12	12	20
Other species	2	3	2
Total	38	61	57

With this brief review of conditions during the past three years a more detailed discussion of the various parasites, treating them by species, may be more easily followed.

Meteorus vulgaris Cress.

This braconid is a parasite of several common cutworms locally. The biology of the species, or of the almost identical *M. dimidiatus* Cress., has been described by Strickland ('23). There are at least two generations a year, adults appearing in May and again in July. The female deposits about twelve eggs in a cutworm. The winter is passed in the larval stage in hibernating cutworms.

One additional note may be made to the habits as described by Strickland. In dry soil the host larvæ may complete their pupal cells before the parasite larvæ emerge, while in extremely wet soil the parasite larvæ may emerge from the host quite early in the sixth instar, or, rarely, in the fifth.

The main causes of the fluctuations in the percentage of parasitism by this species at Saskatoon during the past four years are closely related to the prevalence of *Euxoa tristicula* Morr. which in this region is the principal host of the alternate generation. Larvæ of *E. tristicula* were scarce locally until the

autumn of 1924 when they were present in great numbers. These larvæ overwintered successfully, but in the spring showed a parasitism by *M. vulgaris* of more than 30 per cent. The adult parasites transferred their attentions to the larvæ of *E. ochrogaster*, then also very plentiful, in which they established a parasitism of 30 per cent. Though most of these host larvæ succumbed to disease there was a large flight of adult parasites doubtless producing a high rate of parasitism in the larvæ of *E. tristicula* which were abundant again in the late summer of 1925. However, there was a tremendous fall and winter mortality of *E. tristicula* larvæ that year which so decimated their ranks as to make them quite as scarce in 1926 as in the spring of 1923 or 1924, with the result that the parasitism of *E. ochrogaster* by *M. vulgaris* likewise dropped in 1926 to nearly the same figure as in 1923 and 1924.

Gonia spp.

The main facts in the biology of *Gonia* spp. have been admirably described by Strickland ('23). The salient features for the purposes of the present paper are that there is but one generation a year and that oviposition is on vegetation, the eggs not hatching until they are consumed by the cutworms. Strickland worked for the most part with specimens reared from *Porosagrotis orthogonia* Morr., and recognized that a number of species were involved.

The genus is still in an unsatisfactory condition from a taxonomic point of view. Determination of the species involved is rendered all the more difficult since, under laboratory conditions, the percentage emergence of adults is small. Our material reared to adults consisted of eleven specimens of *G. aldrichi* Toth., two of *G. fusicollis* Toth., and one of an undescribed species. The first mentioned is evidently the most common locally and is also widely distributed throughout the province. In the following discussion no attempt is made to differentiate between the three species.

Interesting and contrasting data were obtained upon oviposition habits. Strickland (l.c.pp.26 and 27) makes the following statements regarding his observations at Lethbridge, Alta. "Few eggs can be found on any plants other than the Graminæ. . . . . Grain crops certainly come next to the grasses in order of selection for oviposition. . . . We observed

no indication of an instinct for laying the eggs on the blades nearest to the ground."

At Saskatoon, different species of this genus exhibited a marked diversity in oviposition habits. Flies of certain species, for example *G. breviforceps* Toth., were observed in activity only over grassland, while those of the species parasitizing *E. ochrogaster* were found almost exclusively in cultivated fields. In these fields, the great majority of the eggs were placed on those plants and parts of plants most readily eaten by larvæ of *E. ochrogaster*, a fact definitely established both by observations of successive deposition of several eggs by each of a number of flies, and by counts of eggs on plants. Thus, in a field of young wheat, sweet clover, and rye grass, the flies were observed to exhibit a marked preference for the clover seedlings. In this particular field 90 per cent of the clover plants were eventually consumed by the red-backed cutworms, while neither the wheat nor the rye grass suffered appreciable injury. Similarly, in a field of wheat alone, the flies oviposited more freely on the young re-growth of plants damaged by cutworms than on the older plants, and again, observations showed that this re-growth was the favoured food of the host larvæ.

The two series of observations indicate that at each place the recorded habits of the parasites involved were so correlated with the habits of the principal host as to prove advantageous to the former. The present writers incline towards the belief that the more recent trend of differentiation is merely a favouring of one or more of the several species of *Gonia* now present, which already possess different habits, rather than a definite immediate biological adaptation on the part of those various species.

It will be noted in Table I. that the parasitism by this genus has not been very heavy during the past four years. Whether it will ever approach the importance with *E. ochrogaster* that it sometimes assumes with *P. orthogonia* is not clear, but Strickland's observations on extreme phagocytosis in the former host suggest, as do our own observations, that the effective parasitism may never be very high.

Sagaritis atkinsoni Vier.

This species was described by Viereck ('26) from adults collected at Rosthern, Sask., in 1923. It has been fairly

abundant at Saskatoon during the past three years and H. L. Seamans has also furnished us with a considerable number of specimens reared at Lethbridge, Alta., in the spring of 1926. The present discussion constitutes the first contribution to the knowledge of its biology.

The only authentically determined host from which we have reared this species is *E. ochrogaster*, though it is not improbable that it parasitizes larvæ of such closely related species as *E. tessellata* Har. or *E. verticalis* Grt. It is readily distinguished from any other parasites we have reared from *E. ochrogaster*, by the unvaried habit of the larva of emerging from the host while the latter is in the fourth instar.

The adults of *S. atkinsoni* are present in the early spring and presumably lay their eggs in the young larvæ at that time. The host larvæ develop normally until within a day or two of the emergence of the parasite larva. The latter larva, emerging from its fourth instar host, spins in the soil a cylindrical cocoon about 7 mm. long, with rounded ends, and composed of whitish, gray or black silk. The adult emerges in a fortnight to three weeks under laboratory conditions, probably taking about the same length of time in the field. The adults of the generation from *E. ochrogaster* thus emerge mainly during the last three weeks of June. What alternate host or hosts carry *S. atkinsoni* over until the following spring is not known since this species has not been secured from any of the several species of fall cutworms reared.

This parasite is of immediate economic value because it destroys the host larva before the latter can do much damage, thus being effective in reducing the damage for the current year as well as the abundance of the host in the succeeding year.

The increase in the rate of parasitism from 1925 to 1926 is attributable to the high mortality of the host larvæ from disease in the former year. This is dealt with further later.

Berecyntus bakeri var. **gamma** Gir.

Like its relative *Copidosoma gelechiæ* How. (Leiby '23) this parasite is polyembryonic, and several hundred specimens emerge from each host larva. The parasite deposits its egg in the host egg but no detrimental effect on the host is observed until the larva is full grown. Indeed the average size and

apparent vitality of full-grown larvæ of *E. ochrogaster* parasitized by *B. gamma* is considerably above that of those not so parasitized. The enlargement in size involves not only the body but also, frequently, the head, and is often associated with an abnormal seventh larval instar which has been observed under no other conditions. In this event the sixth instar tends to be subnormal in size.

The species passes the winter either within the host egg, as in *E. ochrogaster*, or within a hibernating host larva, such as *Chorizagrotis thanatologia* Dyar. The parasites do not become visible within the host until the latter has formed its pupal cell. This has been figured by Gibson ('15, Fig. 8) and described by Snow ('25). The adult parasites emerge in about one month from the time when they are first visible, thus being only a few days later than the corresponding moths would have been.

Parasitism by *B. bakeri* is not specific. At Saskatoon it has also been reared from *Euxoa detersa* Wlk., *E. tristicula* Morr., *C. thanatologia*, *Rhizagrotis flavicollis* Sm., *Feltia venerabilis* Wlk., and *F. ducens* Wlk. It most often is reared from larvæ from cultivated fields.

There is a certain amount of seasonal selection on account of the varying life-histories of the different hosts but the parasites from the seasonal extremes of one host, such as from the late larvæ of *C. thanathologia*, may attack the opposite seasonal extreme of another species, such as the early eggs of *E. ochrogaster*. There are indications that the general rate of parasitism by *B. gamma* of its most abundant host is influenced by an imperfect rhythmical adaptation to that host and consequently by the numbers of larvæ of other host species present. The rate of development of this parasite is more rapid than that of most of its host species in this locality. For example, the peak of abundance in the field of adults of *B. gamma* is evidently considerably in advance of the maximum occurrence of the stage or stages of *E. ochrogaster* which are suitable for attack. Under conditions where this cutworm is outstandingly the most abundant, this results in a marked loss of effectiveness of these parasites, since the majority must depend for survival upon finding suitable stages of less abundant early hosts, such as *F. ducens;* conversely the rate of parasitism of *E. ochrogaster* is low, as the majority of its individuals are exposed to attack only by a small brood of parasites, for the most part made up

of late individuals such as those emerging from late-developing hosts, e. g. *F. venerabilis*. This view seems to be supported not only by field observations on the abundance of parasite adults, but also by the much higher rate of parasitism by *B. gamma* of larvæ of *F. ducens* than of those of *E. ochrogaster* occurring in the same field, a condition which has been definitely established in several instances. Similarly, the relative rate of parasitism in different fields is partially correlated with the extent and variety of the cutworm infestation in each during the previous years.

The increase in the rate of parasitism from 1925 to 1926 may be attributed to a decrease in the abundance of the host and to the advantaging of the species by disease of the host larvæ in 1925 as explained later.

B. MINOR PARASITE

The eleven adults of the family Bombyliidæ reared from pupæ of *E. ochrogaster* represent four species, *Villa halcyon* and *V. willistoni*, four specimens of each, *V. lateralis*, two specimens, and one specimen of *V. fulviana*. The first two species mentioned may emerge in the autumn or may remain within the host pupa until the following June. In the event of their emerging in the autumn they must find an alternate host, probably a noctuid that hibernates as a larva. The other two species emerge in the autumn though probably some also over-winter like the first mentioned species. The members of this family have proved of only very slight economic importance in relation to *E. ochrogaster*.

Strickland ('23) records *Bonnetia comta* as occasionally an important parasite of *P. orthogonia*. During the three years of 1924 to 1926 four specimens have been bred at Saskatoon from larvæ of *E. ochrogaster*. The adults have not been abundant locally during this period.

Phorichaeta sequax. On the basis of adults secured from field cages this tachinid is tentatively recorded as a parasite of the larvæ of *E. ochrogaster*. Economically the species has so far proved negligible.

Apanteles acronyctæ. Two larvæ collected at Saskatoon in 1925 were parasitized by members of this genus. Adults reared from one specimen were determined as the above species.

Paniscus sp. Adults of an external hymenopterous parasite of this genus appear usually from about June 10th, onward and from this date a reddish-brown egg may sometimes be found on one side of the first or second thoracic segment of nearly full grown cutworm larvæ. The biology of some North American members of the genus have recently been given, and several previous references cited, by Vance ('27). In Saskatchewan there are apparently at least two generations per year. The species has been of very minor importance during the period of observation.

Erigorgus sp. Two specimens of this parasite, which passes the winter within the host pupa, were reared from *E. ochrogaster* in the spring of 1925. Another specimen was reared from a pupa of *P. orthogonia*, emerging in the laboratory during the winter of 1925.

C. HYPER-PARASITISM AND SUPER-PARASITISM.

No hyper-parastism has been observed. Super-parasitism frequently occurs, though, since we have not performed dissections in relation to this work, the only observed instances have involved the external *Paniscus* sp. in combination with either *M. vulgaris* or *B. bakeri*. Undoubtedly a variety of other combinations exist. On account of its life history *S. atkinsoni* is probably not involved in super-parasitism except with *B. bakeri*, a further factor increasing the value of the former species.

Disease has the same general result as ordinary insect super-parasitism, very frequently killing parasitized larvæ. The most extreme instance observed was a larva parasitized by both *B. bakeri* and *Paniscus* sp. which died of disease.

DISEASES.

Wardle and Buckle ('23) separate the various diseases caused in insects by micro-organisms into four classes; (1) diseases caused by fungi; (2) diseases caused by bacteria; (3) diseases caused by protozoa; and (4) diseases of unknown origin, but suspected to be caused by micro-organisms.

Lack of time has unfortunately precluded the possibility of any serious laboratory study or any of the diseases of *E. ochrogaster*, the work on them being confined to field and

laboratory observations on larvæ under, or collected from, natural conditions. Consequently the identity of the causative organism can only be suggested for the most part.

Fungus Diseases.

Several disease of the larvæ, evidently of fungus origin, have been encountered. These thrive in cool damp weather such as was prevalent during the latter half of May 1926, when one collection showed a mortality of 16 per cent from this cause. Though fungi play an appreciable part in the control

TABLE II.

Temperature and Precipitation Records at Saskatoon May 13 to June 30, 1923 to 1926.

Week Ending	Mean Temperature, Degrees F.				Precipitation in Inches			
	1923	1924	1925	1926	1923	1924	1925	1926
May 19th	45.1	47.8	49.5	54.8	T	.13	.38	.82
May 26th	63.1	41.6	55.3	51.8	.44	.09	.29	.59
June 2nd	58.5	54.4	57.0	54.4	3.00	T	1.29	.83
June 9th	60.4	53.4	51.6	58.0	.65	.85	2.69	.00
June 16th	71.2	56.7	59.6	53.1	.00	.12	.14	1.09
June 23rd	56.5	56.2	62.6	55.2	3.02	T	1.20	.25
June 30th	58.3	61.5	66.4	66.3	.31	.15	.27	.11
Average	59.1	53.1	57.4	56.2	.....	.....	.....	.....
Total	.....	.....	.....	.....	7.42	1.34	6.26	3.69

of the larvæ, possibly also sometimes attacking eggs and pupæ, their effect is relatively small compared with that of diseases caused by other organisms.

Bacterial Diseases.

The most important disease generally is one the symptoms of which are very similar to those described by White ('23) for cutworm septicaemia, (causative organism, *Bacillus noctuarum* Wh.). In our work we have assumed that the disease or diseases, so closely resembling in symptoms and general reactions that described by White, are caused by *B. noctuarum* or one or more closely related organisms and, to avoid repeated lengthy circumlocutions, have referred to the disease or group of diseases characterized by these symptoms as "disease A."

This disease, which is of general distribution throughout the province, assumes importance whenever the combination of factors favouring it, namely warm, wet weather and an abundance of the host larvæ, occurs. This is well shown by the data presented in Tables II and III, particularly when considered in connection with the rates of infestation in the several years.

All of the estimates in Table III may be a little low because only such mortality as was considered definitely attributable to "disease A" has been included.

Since there was noticeable damage at Saskatoon in 1924 it is obvious that, considering the small number of larvæ present in 1923, disease was not very effective during the latter season

TABLE III.

Approximate Percentage Mortality from "Disease A" of Larvæ of *E. ochrogaster* Collected from Field Conditions at Saskatoon.

Collections of Week Ending	1923	1924	1925	1926
May 19th		0	10	5
May 26th		0	15	10
June 2nd	Insufficient	0	20	15
June 9th	data	0	40	20
June 16th		0	55	40
June 23rd		0	65	30

in spite of weather favourable to it. This may be directly attributed to the scarcity of the hosts. In this connection it is interesting to note that disease was prevalent in 1923 at Rosthern, Sask., under similar weather conditions but where there was a much greater abundance of larvæ.

The cool, dry season of 1924, did not favour the spread of disease in spite of a fair abundance of host larvæ. In 1925 there was a rather dry period up to the end of May, followed by an excessively wet and rather warm June. Combined with the great abundance of larvæ this resulted in a very high larval mortality from parasitism, for the moth emergence from larvæ collected at this time was less than 5 per cent.

In 1926, both temperature and precipitation were intermediate between the extremes of 1923 or 1925 and that of 1924. The mortality from disease, as shown in Table III, was also intermediate, the decline from 1925 being partly attributable also to a reduction in the abundance of the host larvæ. The

decline in disease from 40 to 30 per cent in the last two weeks of this year appears to be directly connected with a scarcity of the larvæ in the field under study during the week of June 23.

"Disease A" causes, under natural conditions a higher mortality among the later instars, particularly the last. Two possible explanations are suggested; first that larvæ in the last stage are more susceptible than they are in the earlier instars (vide White, l.c.p. 492); second that the lower temperatures during the early part of the season are considerably less favourable to the development of the disease than of the host. A factor of probable importance in either instance is the time taken for the infection to spread once it has made its appearance.

This disease is more fatal to larvae of *E. ochrogaster* than to those of most species present with it. This fact was repeatedly evidenced. A typical example is shown by a collection made on June 25, 1925. Fifty larvæ were collected of which thirty-five were determined as almost undoubtedly *E. ochrogaster*. Only four moths were obtained in laboratory rearing, one each of *Euxoa albipennis* Grt., *E. verticalis* Grt., *E. messoria* Har. and *Feltia venerabilis;* all of the above species have life histories similar in the main to *E. ochrogaster*. Species of more dissimilar larval habits, such as *Feltia ducens* and *Porosagrotis orthogonia*, showed an even lower mortality from this cause.

There is evidence of an inter-relation, somewhat on the order of non-obligatory alternate hosts,* between the larvæ of *E. ochrogaster* and *E. tristicula* with respect to "disease A." If true, this is an important exception to the statement made in the preceding paragraph. In the spring of 1925 one field under observation at Saskatoon was heavily infested by *E. ochrogaster* and some *E. tessellata*, while in another field *ochrogaster* larvæ were much less common but *tristicula* larvæ fairly plentiful, over 30 percent succumbing to disease of type "A" symptoms. Larvæ from the first field, collected on May 20 developed only 6 per cent disease, only 2 per cent being of type "A." In contrast, larvæ from the second field, collected six days later, showed a diséase mortality of 30 per cent, 18 per cent being definitely attributable to disease "A," although weather conditions of the intervening six days were unfavourable to the

* It should be noted that *E. Tristicula* hibernates in a late larval stage, usually about 5th instar the larvae being present f;om late summer until near the end of may.

spread of disease. This and various other less definite observations all indicate that the presence of diseased *tristicula* larvæ is an important factor in accelerating the rapidity of development of the disease to epidemic proportions in *ochrogaster*.

A similar phenomenon, but in the reverse direction and not involving the simultaneous presence of the larvæ of the two species, was even more strongly evidenced in the fall of 1925. *E. tristicula* larvæ everywhere in the Saskatoon district showed evidence in the field of disease and the great majority of those brought in died from this cause. Consequently it is believed that disease was the principal factor bringing about the sudden decrease from the great abundance of this species in the early fall of 1925 to its virtual absence in the spring of 1926. On the other hand, in another district where *E. ochrogaster* was not abundant in 1925, *E. tristicula* was again in outbreak form in 1926.

The presence of an alternate host for the disease is not obligatory. This might be expected in view of White's (1.c.p.494) statement that *B. noctuarum* remains viable over long periods in moist soil, and is evidenced in the present instance by the prevalence of disease in 1926. We suggest however, that the much slower increment of disease in the earlier collections of this year, with weather conditions apparently much more favourable to disease development than in 1925, may be partially connected with the virtual absence of *tristicula* larvæ in the spring of 1926.

Diseases of Unknown Origin.

During the summer of 1925 there was, in the vicinity of Saskatoon, another disease of great importance in some fields. The sick larvæ crawled up nearby objects such as posts, sticks, pieces of stubble or blades of grain. Within a few hours they died and within twelve hours the blackened, dry skins could be found, the contents of the body having almost entirely disappeared. The bodies collapsed dorso-ventrally and were firmly attached by the thoracic legs to whatever objects the larvæ were upon at the time of death.

We possess no evidence of the nature of the causative agent of this disease. The symptoms were observed only at Saskatoon and principally in one field very heavily infested by cutworms. The essential environmental conditions probably approximate

those necessary for disease "A," possibly requiring an even more dense larval population. In the heavily infested field just referred to this disease, with slight assistance from other natural control factors, was responsible for the complete annihilation of the *ochrogaster* larvæ.

This disease, like "disease A," was more fatal to larvæ of *E. ochrogaster* than to those of other species, but, so far as could be observed, caused as high a mortality among fourth and fifth instar larvæ as to those in the sixth. On account of its apparently limited distribution it was not of as great importance as disease "A."

TABLE IV.

Mortality of *E. ochrogaster* from Insect Parasitism and "Diseases" of Larvæ and Pupæ at Saskatoon During 1925.

Date of Collection	Gonia spp.	Meteorus vulgaris	Sagaritis atkinsoni	Berecyntus bakeri	Other Species	Total	Mortality from "Disease"	Moths Emerging*
							%	%
May 15th	.....	.....	4.2	16.6	.....	20.8	16.6	62.6
May 20th	.....	.....	7.8	2.0	.....	9.8	5.9	84.3
May 26th	2.5	.....	5.0	7.5	2.5	17.5	30.0	52.5
June 9th	10.0	8.0	.....	4.0	.....	22.0	54.0	24.0
June 10th	5.0	15.0	2.5	.....	.....	22.5	60.0	17.5
June 10th	.....	15.0	.....	5.0	2.5	22.5	60.0	17.5
June 12th	3.3	13.3	.....	.....	3.3	19.9	63.5	16.6
June 25th	2.0	12.0	.....	12.0	6.0	32.0	66.0	2.0
June 25th	3.0	8.0	.....	6.0	3.0	20.0	80.0	0.0

INTER-RELATION OF PARASITISM AND DISEASE.

The data which form the basis of this discussion are taken almost entirely from the records obtained at Saskatoon during the summer of 1925. The use of the records from but one locality, gives the great advantage of more uniform environmental conditions, especially weather, prevalence of disease and prevalence of various parasites. The conclusions reached were originally formulated during the winter of 1925 and were in the main amply substantiated by the developments of 1926.

In Table IV are presented the records of nine collections of larvæ made at Saskatoon during 1925. Each collection con-

*Includes also a few moths of species closely related to *E. ochrogaster*, whose larvæ could not be distinguished from the latter at time of collecting.

sisted of from twenty-five to fifty larvæ, handled in the manner already referred to. Under the heading "Disease" is included all larval or pupal mortality, except that caused by parasites, and, while a small proportion of this is creditable to other influences, the experience of other years, (cf. Table III, 1924) indicates that on the average, fully 90 per cent is directly attributable to this cause.

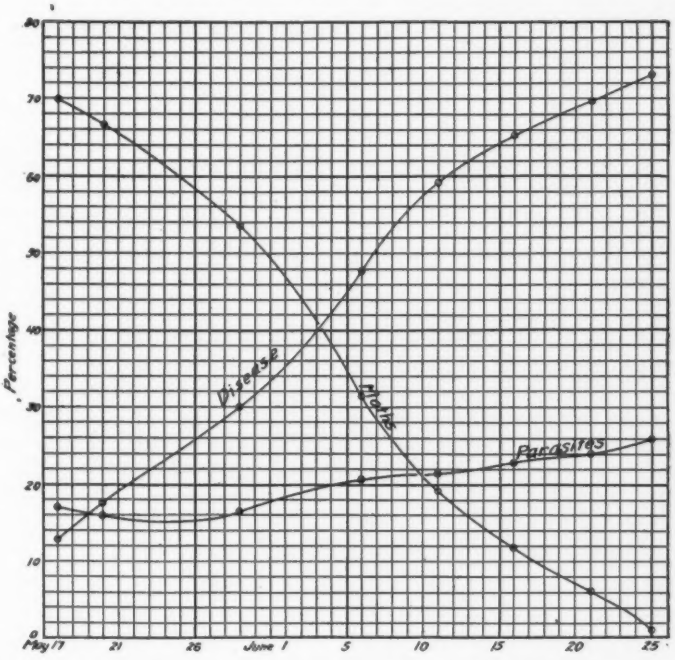


FIG. 1. Graphic representation of the mortality of *E. ochrogaster* from insect parasitism and "diseases" at Saskatoon, 1925. (For explanation see text).

In figure 1 the data of Table IV are presented in the form of a graph. The three variables of moth emergence, mortality from disease and mortality from parasitism are represented by three smoothed curves obtained by taking the mean of the three adjacent values for each point plotted. In addition, the variable of time has been corrected to compensate for the unequal intervals between collections. Thus the values plotted

for June 6th. are taken from the data of May 26th, June 9th and June 10th, and similarly for the other dates. Under the conditions of this year the curves closely approximate straight line functions, but it cannot as yet be stated that this relationship would hold under less uniform conditions.

This chart shows that the mortality from disease rose from 13 per cent on May 17th. to 73 per cent on June 25th. while, during the same period, the moth emergence fell from 69.8 per cent to 1 per cent. The average rate of moth emergence for all larvæ in the locality as a whole was estimated to have been about two and one-half per cent, the result of survival of early individuals in lightly infested fields.

A comparison of the parasitism curve with the other two, yields, however, the most important information. The slight decline from May 17th. to about the 24th. of that month is due to the presence of *S. atkinsoni* in the earlier collections and its natural absence from the later ones. The subsequent gradual rise in the percentage of parasites emerging is due to increasing parasitism by *M. vulgaris*, *Gonia* spp. and a few minor parasites, greatest effect being attributable to the first mentioned species. The most significant fact is that, during the period of June 15th. to 25th., which may be taken as representing approximately the final conditions in moderately infested fields in this year, the percentage of parasite emergence increased from 23 to 26 while the percentage of moth emergence decreased from 13 to 1.

The significance of this becomes more evident when it is remembered that the estimated effective parasitism for this year as given in Table I was only 61 per cent. If disease had not been prevalent the proportion of hosts from which parasites emerged to the number of moths emerging would have been approximately three to two. As it finally developed it was more nearly in the neighbourhood of twenty to one, for, it must be remembered, practically all of the larvæ of *S. atkinsoni* emerged from their hosts before there was a high mortality from disease, though naturally this is not shown in the portion of the graph under discussion. Therefore disease was not only of great effect in destroying most of the larvæ present in 1925 but also was effective in greatly increasing the proportion of parasites to moths emerging, thus favouring the possibility of high parasitism in 1926.

The differential death rate did not affect all species of parasites equally, this depending largely on the time of emergence of the parasite from the host.

S. atkinsoni. By emerging from a fourth instar host, this species was at great advantage since it was able to complete its development in almost all instances without interference from disease. This advantage is reflected in the increased parasitism in 1926, which also indicates that the alternate host or hosts were reasonably abundant.

M. vulgaris. The increase of this parasite also was greatly favoured by the intervention of disease, for, as already mentioned, it may emerge from its host quite early in the sixth instar in wet soil. This potential advantage was completely nullified, so far as *E. ochrogaster* in 1926 was concerned, by the exceedingly high mortality of the principal alternate host *E. tristicula.* As has already been suggested this may have been due to the same disease. In that case the transference of the disease to *tristicula* more than offset the advantage which the parasite derived from the abnormal mortality of *ochrogaster.* Such a condition would probably occur only in years when the soil moisture in September was well above the average.

B. bakeri. It is evident both from its rate of emergence in 1925 and from the increase in the rate of parasitism by it, in 1926, that this species also received an advantage from the prevalence of cutworm disease. The reason for this is not apparent, however, since the parasite does not kill its host until the latter has formed its pupal cell, and indeed such host larvæ have a longer average period of feeding than normal larvæ. The only suggestion that can be made is that this observed advantage may be connected with the apparently increased metabolic activity of the host until just prior to its destruction by the parasite, a condition evidenced by its voracity, larger size and often by an additional instar. Until more is known of the pathology of the disease and the relations of the host to the parasite no definite cause can be ascribed.

Minor parasites. Possibly all minor parasites derived some slight benefit but have not shown any marked variations. Our knowledge of the biology is too incomplete to permit any explanations.

Gonia. The only parasites not favoured were the several species of this genus. The tentative conclusion from the evidence is that the rate of emergence of this fly relative to that of its host species would have been higher had there been no cutworm disease. Observations indicated that this parasite lowers the vitality of the host some time before the completion of its own development, and thus increases the host's susceptibility to disease.

GENERAL CONCLUSION.

It has been shown in the previous pages that the main control factors of the immature stages of *E. ochrogaster*, from the beginning of the fourth instar onwards, are parasites and diseases. In their general relations to the occurrence of their host these two factors exhibit a wide divergence. The total parasitism tends to remain fairly constant, thus having a regulative action upon the oscillations of the insect, and increasing the average length of time between successive outbreaks. Diseases, on the other hand, only become of major importance when the insect has already increased to far beyond its average abundance, (cf Howard & Fiske, '11, p.108), a condition which *E. ochrogaster* does assume at frequent intervals. We have no evidence that parasites are ever likely to increase to sufficient numbers to control the periodic outbreaks of *E. ochrogaster* as they do those of certain arboreal Lepidoptera e.g. *Hemerocampa leucostigma* A. & S. (Howard '97), and other insects. The principal reason for this is that the parasites are unable to increase their numbers with sufficient rapidity to control an outbreak before disease has already effected control. Disease, therefore, is for *E. ochrogaster* the most effective factor in reducing outbreaks,* and in addition may tend to increase the general rate of parasitism the following year, a tendency which however may be more than offset by the subsequent intervention of other factors.

---

*This conclusion is at variance with the statement by Strickland ('23, p. 4), referring to prairie cutworms including *E. ochrogaster*, that "Each species of cutworm has its complement of native parasites which constitute the most effective factors in reducing outbreaks."

SUMMARY.*

The paper deals with the biological natural control factors of the immature stages of the red-backed cutworm *Euxoa ochrogaster* Gn., as observed in Saskatchewan during the four years 1923 to 1926, a period which included the climax of an outbreak of the species. It treats principally of those factors operative from the beginning of the fourth instar until moth emergence. A list of fifteen reared parasites and a discussion of their relative importance is given. Estimates of the annual fluctuations in the abundance of the major species of parasites are made and some of the causes of these fluctuations are outlined. The various diseases encountered and their relative importance are discussed. This is followed by an analysis of an important inter-relation of parasites and disease and a discussion of the parts played by each of these factors.

Predators are considered of relatively minor importance. The four principal parasites dealt with are *Gonia* spp., *Meteorus vulgaris*, *Sagaritis atkinsoni*, and *Berecyntus bakeri*. The most important disease encountered is, or closely resembles, cutworm septicaemia and assumes epidemic proportions when continued warm, wet weather is combined with an abundance of the host larvæ. This disease favours an increase in the rate of parasitism of the host the following year since in most cases it destroys a much greater proportion of unparasitized than of parasitized larvæ, due largely to several parasites completing their development prior to the period of maximum disease mortality of the host. Disease is for *E. ochrogaster* the most important factor operating in causing the rapid decline

*Of special interest to the present discussion is the article by A. Paillot (Le problème l'équilibre naturel chez les insects phytophages. Revue génerále des Sciences pures et appliqueés, 36, 7, 206-211, April 15, 1925), relative to *Pieris brassicae* L., to which the writers' attention was drawn by Dr. L. O. Howard, at the time of presentation of this paper at Nashville. We are indebted to Dr. Howard also for a manuscript copy of his translation of it. Like Paillot, the present writers have endeavored in so far as available facts permitted, to consider all the biotic factors, affecting the one host species during an important period of development, as a whole in their mutual interactions with each other and as influenced by other host species; the future ideal is "A complete and definite analysis of the problem of natural equilibrium between the plant-feeding insect and its parasites" (in the broadest sense). The conclusion, tentatively expressed by the present writers, relative to the interaction between diseases and insect parasites of *E. ochrogaster*, gains considerable support from findings of Paillot, based as the latter are on detailed study simultaneously by specialists both in insect parasitism and in micro-parasites.

from the peak of an outbreak, although parasitism is of importance in reducing the subsequent rate of increase.

LITERATURE CITED.

Gibson, A. 1915. Cutworms and their Control. Can. Dep. Agr., Bull. 10.

Howard, L. O. 1897. A Study in Insect Parasitism. Bull. U. S. D. A., Div. Ent., Tech. Ser. 5.

Howard, L. O. and **Fiske, W. F.** 1911. The Importation into the United States of the Parasites of the Gipsy Moth and the Brown-tail Moth. U. S. D. A., Bur. of Ent. Bull. 91.

King, K. M. 1926. The Red-backed Cutworm and its Control in the Prairie Provinces. Can. Dept. Agric. Pamph. 69, N. S.

King, K. M. and **Atkinson, N. J.** 1926. The relation of the Red-backed Cutworm to Diversified Agriculture in Western Canada. Sci. Agri. 7: 86-91.

1927. Quantitative Methods of Collecting and Rearing Soil Cutworms. Jour. Ecom. Ent. 20, No. 6.

Leiby, R. W. 1923. The Polyembryonic Development of Copidosoma gelechiae How., with Notes on its Biology. Jour. of Morph., 37: 195-285.

Snow, J. S. 1925. Observations on the Cutworm Euxoa auxiliaris Grt. and its Principal Parasites. J. E. E. 18: 602-609.

Strickland, E. H. 1923. Biological Notes on Parasites of Prairie Cutworms. Can. Dep. Agri. Bull. 26. N. S.

Vance, A. M. 1927. On the Biology of Some Ichneumonids of the Genus Paniscus Schrk. Ann. Ent. Soc. Amer. XX: 405-417.

Viereck, H. L. 1926. A Preliminary Revision of the Campopleginae in the Canadian National Collection. Can. Ent. 58; 38.

Wardle, R. A. and **Buckle, P.** 1923. The Principles of Insect Control. Manchester, Univ. Press.

White, G. F. 1923. Cutworm Septicaemia. Jour. Agr. Res., 26: 487-495.

Whitehouse, F. C. 1921. Entomological Report for 1920. Ann. Rept., Dept. of Agri., Alta., 1920; 191-193.

STUDIES ON THE BIOLOGY OF THE GENUS CORIZUS
(Coreidæ, Hemiptera)

P. A. Readio,
University of Kansas.

INTRODUCTION.

The genus Corizus is one which has offered considerable difficulty to taxonomists. Individual variations in size and color have made for difficulty in limiting species and have caused the naming of doubtful species and varieties. The more recent taxonomic reviews of the genus by Hambleton (1) and Gibson (2) have done much to simplify the indentification of our forms. Hambleton's excellent monograph of North and Middle American species, with its numerous illustrations, is particularly valuable, and Gibson's review of Hambleton's work is useful because of its considerations of phylogeny, and suggestions in regard to possibly synonymous forms. Both of these writers speak of the necessity of biological data in solving the taxonomic problems of the genus. Hambleton says, "Any attempts to trace the lines of dispersal or phylogeny of this genus must be merely tentative until more is known of their life histories, food plants, etc." Gibson states, "After several months of studying long series of specimens representing each species that occurs in North America and many exotic species the author comes to the conclusion that no satisfactory results, as to the limits of each species, the systematic arrangement and relation of species, can be obtained from the mere examination of dried adult specimens, especially without an increased biological knowledge of the group. The writer, therefore, is forced to call tentative any remarks or deductions herein set forth until they are verified by results obtained from life-history and habit studies of each species."

The present paper attempts to supply some of the needed biological data.

PREVIOUS WORK.

Previous work on the biology of members of this genus is not abundant. A note which tells of the finding of large

numbers of *Corizus hyalinus* (Fabricius) on a species of Euphorbia is contributed by Osborn (3). The most complete discussion of any of the species is that given in Hambleton's (4) paper of the life history of *C. lateralis* (Say). In this he gives data on food plants, oviposition, number of generations, behavior of nymphs, lengths of stages, hibernation, and describes and figures the eggs and the five nymphal instars. Heidemann (5) has described and figured the egg of *C. sidæ* (Fabricius). Blatchley (6) gives notes in regard to food plants and hibernation of several species. The present paper presents descriptions and figures of the eggs of *hyalinus*, *sidæ* and *lateralis*, and of the five nymphal instars and adults of *hyalinus* and *sidæ*, together with notes on the biology of the three species.

Habitat: The members of this genus are to be found chiefly on low plants, weeds, etc., in waste places, along the borders of fields, at the edges of roads, along railroad embankments, etc. Blatchley has recorded *lateralis* from the bloom of redbud, *Cercis canadensis* L., and *bohemanii* Signoret from bloom of dogwood, *Cornus alternifolia* L.

Food Plants: As far as present records are concerned, the indications are that the members of this genus are not confined to single species of food plants.

Hyalinus has been recorded as feeding on a species of Euphorbia by Osborn, and Blatchley reports it as feeding on weeds and grass. The present writer has reared it through the whole course of its life cycle on a wild lettuce, *Lactuca scariola* L. and has observed numerous adults, nymphs and eggs on this plant in the field. Eggs of this species have also been found on a seed pod of velvet leaf, *Abutilon theophrasti* Medic., and the young have been reared through to the fifth instar on this plant.

Of *viridicatus* (Uhler), Uhler (7) says, "It lodges in the flowers of various weeds and seems to be common upon the plains, foothills and parks in the mountains."

Hambleton (4) has reared *lateralis* through the whole course of its life cycle, and considers *Polygonum pennsylvanicum* L. the normal host, since the eggs are laid on this species. He found that both nymphs and adults would feed on *Polygonum persicaria* L. also, but that the adult females would not oviposit on this plant. Blatchley reports taking *lateralis* in May and June from "foliage of various kinds, especially that of redbud,

Cercis canadensis L., along the borders of thickets and in open woodland."

Sidæ has been reported as having been taken from low herbage, "especially that of the prickly sida, *Sida spinosa* L.," by Blatchley. The writer has had difficulty in getting this species to thrive on Sida, though it has been seen to feed on this plant when confined. In the vicinity of Lawrence, Kansas, it has been found as nymph and adult on the seed pods of velvet leaf, *Abutilon theophrasti* Medic. Furthermore, eggs have been laid on this plant in the laboratory, and the nymphs reared through two instars before the cold weather put an end to the food supply.

Blatchley reports that *bohemanii* is found in autumn on weeds along the margins of meadows and roadsides, and in early summer on flowers of shrubs along the borders of thickets, especially those of dogwood, *Cornus alternifolia* L.

Food plants of other species have not been recorded.

Feeding Habits: The insects of this genus seem to prefer the reproductive parts of plants. The buds, flowers, seeds and fruits are sought particularly, although the writer has seen *hyalinus* feed on the leaves and stems of *Lactuca scariola* L.

The feeding of the newly hatched *hyalinus* was watched and found to be very interesting. In this insect, the labium is very long, extending beyond the tip of the abdomen when at repose. At the commencement of feeding it is brought forward, and its tip applied to the portion of the plant about to be pierced. It is straight, or only slightly bent at this stage. The stylets are now extruded from the tip and pierce the plant tissues. The labium bends at the junction of the first and second segments, so that the first segment is bent back against the ventral side of the head, with the second segment bent forward and lying against the first. The stylets do not follow the bend, but extend from the head directly to the third segment, which, with the fourth, is still vertical. The bending of the labium, of course, allows the stylets to be inserted more deeply into the plant. After the stage described above has been reached, the entire labium is removed from contact with the stylets, and folded in its normal position under the body. This permits still deeper penetration of the stylets, and they may be inserted for almost their full length, so deeply that at times the labrum comes in contact with the surface of the plant and is bent

outward at the tip. At the conclusion of feeding the stylets are withdrawn, the labium brought forward again, and the stylets replaced in the groove of the labium with the assistance of the front tibiæ, the tips of which are used in guiding and forcing them into place. Just how common this method of feeding is in the genus the writer can not say. It has been observed occasionally in nymphs of all instars in *hyalinus*. Many times, however, the feeding is accompanied only by the bending of the labium at the first joint.

Seasonal Life History: The evidence indicates that members of this genus hibernate as adults, as do most of the Hemiptera. While Hambleton did not find *lateralis* in hibernation, he believed that it must hibernate as an adult. The writer has confined and observed adults of *hyalinus*, *sidæ* and *lateralis* late in October, and the indications are that all three hibernate as adults. There seems to be some difference in the tendency to hibernate, however. *Hyalinus* and *sidæ* will continue to deposit eggs as long as food is supplied to them and the temperature is warm, but *lateralis* adults apparently stop oviposition in late October, or before, even though confined in a warm room and supplied with an abundance of food. Dissection of such individuals showed immature reproductive organs. Blatchley reports hibernation of *lateralis* as an adult, "beneath cover on the ground and beneath loose bark of logs and snags," and that *bohemanii* also probably hibernates as an imago.

The insects are present in the field during the greater part of the warm season, and undoubtedly pass through several generations a season. Hambleton thinks it likely that more than one generation may be reared during the season, since *lateralis*, the species with which he worked, has a developmental period of 20 to 21 days. Uhler (8), if one may judge from the following statement, considered it to have two generations a year: "In Maryland it may be found by beating rank growths on the borders of woods; the first brood late in May to early in July, the second August—October. It hibernates as an adult." The writer has reared *hyalinus* through two successive generations in the summer, and sees no reason why these may not have been preceded and followed by others in nature. The insect has been reared from adult to adult in 17 days, and since the preoviposition period has been found to be only 3 to

4 days, there seems to be no reason why 4 or 5 generations should not be passed through during the season. The adult life is comparatively long, one adult female having been kept in confinement for 50 days.

Eggs and Oviposition: The eggs are deposited on the stems, leaves, flower parts, buds, or seed pods of the food plants. Hambleton found the eggs of *lateralis* attached to the petioles of *Polygonum pennsylvanicum* L., in clusters from 2 to 12, each egg attached to the plant by means of a fine thread from 1 to 2 millimeters in length. Hambleton's figure of the eggs shows that the threads are attached to the plant at a single point and radiate out to the individual eggs of the mass.

In *hyalinus*, the writer found the eggs attached to almost any part of the common food plant, *Lactuca scariola* L., but more commonly on, or in the vicinity of the flowering parts. The eggs of this species are laid in a one-layered mass of any number up to fifty, single eggs being found only rarely. Each egg is attached to that portion of the plant directly beneath it by means of a short pedicel, about .03 mm. long. There are no threads attaching all of the eggs of the mass at a single point as figured by Hambleton for *lateralis*. One female *hyalinus* deposited 558 eggs during 50 days of confinement.

The eggs of *sidæ* are also in one-layered masses, and have been taken on the petioles, seed-pods, and buds of *Abutilon theophrasti* Medic. Masses composed of 7 to 20 eggs have been found, and these are attached as are the eggs of *hyalinus*, by means of a short pedicel, about .06 mm. long.

Length of Stages: Hambleton has recorded the following lengths of stages for *lateralis:* Egg, 6 days; first stage, 2 to 3 days; second stage, 2 to 4 days; third stage, 3 to 5 days; fourth stage, 5 to 7 days; fifth stage, 3 to 9 days.

The writer has reared *hyalinus* and found the following lengths of stages: Egg, 6 to 7 days; first stage, 2 days; second stage, 2 days; third stage, 1 to 2 days; fourth stage, 2 days; fifth stage, 2 to 3 days; preoviposition period, 3 to 4 days. These rearings were conducted at Lawrence, Kansas, during late August and early September, 1927. At this season the temperature was high, the thermometer reaching the high eighties and nineties during the middle of the day. The insects were reared in an out-door insectary, confined in glass stender dishes, and fed daily with pieces of the food plant.

Very little variation in the lengths of stages of the twenty individuals reared in this way was shown.

Sidæ has not been reared through its complete life cycle. The writer has obtained eggs from confined adults kept in a warm room during late October and early November. These eggs hatched in from 10 to 11 days, but probably would have hatched in a shorter time out-of-doors in the summer. There is no reason to think that the lengths of stages of *sidæ* should vary greatly from those of *lateralis* and *hyalinus*, which are short.

Descriptions of Immature Forms:

Corizus hyalinus (Fabricius).

Egg: (Pl. X, Figs. 1, 2): Length, .75 mm.; width, .47 mm.; depth, .52 mm. Red in color during all stages of incubation. Viewed from above, oval in shape, widest somewhat caudad of middle; anterior end with oval cap, rather poorly defined; side away from attachment narrowed, and slightly depressed medially; two chorial processes at anterior end, one on anterior end of cap, the other at anterior end of egg below cap, close together, projecting .05 mm., each with slender base and globose apex, with distinct openings, that of cap facing upwards, that of chorion below cap facing downwards; pedicel for attachment of egg present on under side, somewhat caudad of middle, projecting .03 mm.

First nymphal instar (Pl. X, Fig. 3): Length, when newly hatched, 1 mm., when full fed, 1.5 mm.; length of fourth antennal segment, .36 mm.; length of front femur, .29 mm. Color reddish, upper surfaces of head, pro- and mesothorax, of antennæ, legs, and rostrum darker, metathorax and abdomen lighter. Rather short and stout, head and thorax large in proportion; apex of beak extended well beyond tip of abdomen in newly hatched individuals, to base of abdomen only in full fed individuals; antennæ and rostrum 4-segmented, tarsi 2-segmented in this and all nymphal instars; openings to dorsal stink glands small, inconspicuous, at anterior margins of segments 5 and 6 in this and all nymphals instars.

Second nymphal instar (Pl. X, Fig. 4): Length, from 1.7 to 2.3 mm.; length of fourth antennal segment, .52 mm.; length of front femur, .5 mm. Color reddish, upper surfaces of head and pro- and mesothorax, legs, rostrum, and antennæ reddish fuscous; abdomen with median whitish region at base, extended over metathorax as well as over first three abdominal segments; dorsum of segment five with two very conspicuous white dots, and a whitish median spot near apex; extreme apex fuscous; abdomen otherwise reddish.

Third nymphal instar (Pl. X, Fig. 5): Length, 2.4—2.9 mm.; length of fourth antennal segment, .72 mm.; length of front femur, .6 mm. Upper surfaces of head, prothorax, except light lateral margins, mesothorax, and wing pads fuscous; legs and antennæ somewhat lighter, spotted with fuscous, tinged with reddish; abdomen mostly reddish,

lighter at lateral margins, with median portions of segments 1 and 2, as well as of metathorax, a conspicuous pair of spots on disk of segment five, and a larger median spot near apex white; extreme apex fuscous; openings to dorsal stink glands outlined in fuscous. Wing pads present, short, not reaching apex of metathorax; anterior margin of segment six turned cephalad medially, in region of stink gland opening.

Fourth nymphal instar (Pl. X, Fig. 6): Length, 3.3—4.3 mm.; length of fourth antennal segment, .95 mm.; length of front femur, .81 mm. Similar to preceding in color and structure. An additional pair of small white spots on segment four of abdomen in some specimens. Wing pads larger, extended to, or almost to apex of first abdominal segment; abdomen less swollen in proportion to width of thorax.

Fifth nymphal instar (Pl. X, Fig. 7): Length, 4.3—5.3 mm.; length of fourth antennal segment, 1.2 mm.; length of front femur, 1.1 mm. Head dark at base, lighter at apex, spotted with fuscous and reddish; eyes reddish; antennæ, except fuscous apical segment, light, spotted with reddish fuscous; pronotum and wing pads fuscous with light lateral margins; meso- and metanota light on disk between wing pads; legs, except fuscous apical tarsal segment, light, spotted with reddish fuscous; abdomen as in preceding instars. Thorax and abdomen of more nearly equal width; wing pads well developed, extended to fifth abdominal segment in newly molted forms, to apex of third segment in full fed individuals; other structures as in preceding.

Corizus sidæ (Fabricius).

Egg (Pl. XI, Figs. 1, 2): Length, .9 mm.; width, .55 mm.; depth, .63 mm. Color yellowish when deposited, turning to red as incubation progresses. Oval in shape, widest at or near middle; anterior end with poorly defined, oval cap; narrowed on surface away from point of attachment in mid-region, and slightly depressed here; with two chorial processes, one at about middle of cap, the other on under side of egg at anterior end, distant from first, these short, broad, projecting .03 mm. from surface of egg; pedicel present on under side slightly caudad of middle, projecting .06 mm. from surface of egg.

First nymphal instar (Pl. XI, Fig. 3): Length, when newly hatched, 1.2 mm.; when full fed, 1.7 mm.; length of fourth antennal segment, .18 mm.; length of front femur, .33 mm. General color reddish, with head, pro- and mesonota, antennæ, rostrum, legs except tarsi, and extreme tip of abdomen darker; abdomen lighter red; tarsi dirty white, dorsum of first abdominal segment with median white spine. Beak and antennæ 4-segmented, tarsi 2-segmented in this and all nymphal instars; beak extended beyond apex of abdomen in newly hatched individuals, hidden beneath abdomen in full fed individuals; antennæ, legs and body clothed with long, stout, conspicuous hairs; openings of dorsal stink glands present at anterior margins of segments five and six of abdomen in this and all nymphal instars.

Second nymphal instar (Pl. XI, Fig. 4): Length, 2.3 mm.; length of fourth antennal segment, .4 mm.; length of front femur, .45 mm. General color lighter, head mostly brownish yellow with few paler

markings, eyes reddish, antennæ with first three segments stripped longitudinally with alternate light and dark lines; pro- and mesonota mottled with brown, red and white; metanotum and abdomen chiefly reddish, with white markings; femora and tibiæ with transverse reddish bands; white spine on first abdominal segment as in preceding.

Third nymphal instar (Pl. XI, Fig. 5): Length, 3 mm.; length of fourth antennal segment, .57 mm.; length of front femur, .6 mm. Color much as in preceding with addition of rather regular rows of black spots on abdominal segments, particularly conspicuous on segments 2 and 6; segment 6 of abdomen with preponderance of white; median dorsal spine on first abdominal segment as in preceding; wing pads present, very short and inconspicuous, especially metathoracic pads.

Fourth nymphal instar (Pl. XI, Fig. 6): Length, 4.1 mm.; length of fourth antennal segment, .63 mm.; length of front femur, .8 mm. Color very similar to that of preceding; white spine of first abdominal segment black-tipped in some specimens. Wing pads longer, extended to base of second abdominal segment, mesothoracic pads with yellowish brown spot at base near lateral margin, remainder fuscous.

Fifth nymphal instar (Pl. XI, Fig. 7): Length, 5.2—6.4 mm.; length of fourth antennal segment, 1.1 mm.; length of front femur, 1.3 mm. Head yellowish, with lighter mottling, eyes yellowish, antennæ with first three segments alternately striped with light and dark longitudinally, fourth segment fuscous; pro- and mesonota mottled fuscous and white with traces of red, mesothoracic wing pads with yellowish area extending along lateral margins from base to beyond middle, apex fuscous; abdomen chiefly reddish and white, in varying proportions in different specimens, with a somewhat, but not entirely regular row of black dots on each segment; femora and tibiæ banded with transverse fuscous bands, somewhat interrupted. Wing pads extended to middle of third abdominal segment; first abdominal segment with white median dorsal spine; openings to dorsal stink glands present at anterior margins of segments five and six, median portion of suture between abdominal segments four and five turned caudad, and that between five and six turned cephalad.

Corizus lateralis (Say).

Although Hambleton described the eggs and nymphal instars of this insect, he did not have the opportunity afforded to the present writer of comparing the immature stages of *lateralis* with those of other species of the genus. Unfortunately the writer has only the egg, and the fourth and fifth nymphal instars of this species.

Egg (Pl. X, Figs. 9, 10): Hambleton has described the egg as follows:

"In size, .5 by .7 mm.,—oval when viewed from the side but somewhat triangular when viewed from the end.

"Color: Yellowish, pale, turing red before hatching. Attached by slender thread to petioles of host plant in clusters of two to twelve."

Since Hambleton did not mention nor figure the structures of the egg which in *hyalinus* and *sidæ* seemed to the writer of the most significance, that is, the cap, the chorial processes, and the pedicel, a special attempt was made to get the eggs of this species to see if they were radically different. Adults were collected, confined, and fed, but it was already late in the season and no eggs were deposited. Dissection showed the ovaries of the female to be in immature condition. However, dried pinned specimens that had been collected during the summer were boiled, dissected, and found to contain eggs in nearly perfect condition.

These eggs (Pl. X, Figs. 9, 10) were found to be similar to those of both *hyalinus* and *sidæ* in general shape, the narrowing in the mid region of the side away from the point of attachment, the position of the cap, and the possession of chorial processes and pedicel. They resemble the eggs of *sidæ* and differ from those of *hyalinus* in being widest in the mid region, possessing short, inconspicuous chorial processes, and in the position of the upper chorial process in the middle of the cap. They resemble the eggs of *hyalinus* and differ from those of *sidæ* in the position of the lower chorial process at the anterior end of the egg, just below the cap, and in the shorter pedicel. They differ from both in that the constricted middle region on the upper side is narrower, .23 mm., in *lateralis*, and wider, .45 mm., in *hyalinus* and *sidæ*.

Nymphs: The fourth and fifth instar nymphs of *lateralis* resemble those of *sidæ*, amd differ from those of *hyalinus* in general shape; in the possession of a median spine on the dorsum of the first abdominal segment; in the banding of the legs; in the longitudinal striping of the first three antennal segments; in the greater degree of hairiness. They differ from both of the other species in color pattern, most conspicuously in having the veins of the mesothoracic wing pads outlined in black.

CONCLUSION.

In conclusion it may be well to call attention to the fact that in this genus specific characters are present to at least as great a degree in the eggs and nymphs as in the adults. The

eggs, while small, show distinct and constant differences, and the nymphs, the later instars particularly, show specific differences more easily recognized than those of the adults. The taxonomist would find it to his advantage to take cognizance of such differences.

Furthermore, evidences of relationship, or lack of relationship, may be obtained by a study of immature forms. Hambleton has taken advantage of this fact in his studies of the genus. In his earlier paper (1) he states that *sidæ* originated in Central America or the West Indies, and that *lateralis* has probably sprung from the *hyalinus* type. Later (4), after having studied the immature forms of *lateralis*, he makes the following statement:

"There is one character to all the nymphal stages of this insect except the first, which gives some insight into its phylogeny. This is the banded legs. These are lost in the adult *lateralis*, but are present in *sidæ*, its tropical relative, which barely reaches our southern borders. This seems to indicate that probably *sidæ* is the progenitor of *lateralis* and that this change has probably been the effect of climate."

Whether *sidæ* is the progenitor of *lateralis*, or *lateralis* of *sidæ*, or both have come from a common ancestor, the writer has no evidence; but it is certain that the two are much more closely related to one another than either is to *hyalinus*, and that Hambleton's statement after having studied the immature stages of *lateralis* was much nearer the truth than his earlier statement which linked *lateralis* with *hyalinus*. It seems to the writer that further studies of the immature stages of this and other genera would be of valuable assistance in drawing conclusions as to phylogeny.

LITERATURE CITED.

1. **Hambleton, J. C.** 1908. The Genus Corizus with a Review of the North and Middle American Species. Ann. Ent. Soc. Am., I: 133-152, pls. 8-11.
2. **Gibson, E. H.** 1919. Notes of the North American Species of Corizus. Can. Ent., LI: 89-92.
3. **Osborn, Herbert.** 1904. Observations of Some of the Insects of the Season in Ohio. Bull. U. S. Dept. Agr., Div. Ent., 40: 89.
4. **Hambleton, J. C.** 1909. Life History of Corizus lateralis Say. Ann. Ent. Soc. Am., II: 272-276, pl. 29.
5. **Heidemann, Otto.** 1911. Some Remarks on the Eggs of North American Species of Hemiptera-Heteroptera. Proc. Ent. Soc. Wash., XIII: 132, pl. IX, fig. 9.
6. **Blatchley, W. S.** 1926. Heteroptera of Eastern North America. Genus Corizus, pp. 276-283.
7. **Uhler, P. R.** 1877. Report Upon the Insects Collected by P. R. Uhler During the Explorations of 1875. Bull. U. S. Geol. Geog. Surv. Terr., III: 407.
8. **Uhler, P. R.** 1876. List of Hemiptera of the Region West of the Mississippi River. Bull. U. S. Geol. Geog. Surv. Terr., (2) I: 301.

EXPLANATION OF PLATES.

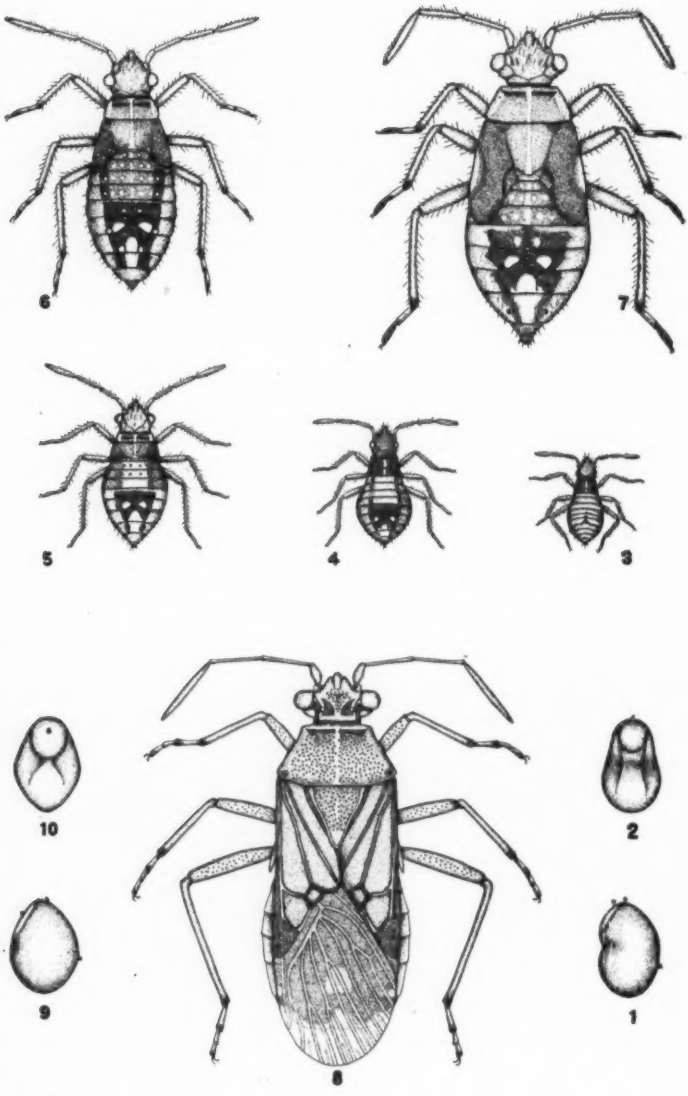
PLATE X.

Fig. 1. Egg of *Corizus hyalinus*, lateral view, × 58.
Fig. 2. Egg of *C. hyalinus*, viewed from above, × 58.
Fig. 3. First nymphal instar of *C. hyalinus*, × 29.
Fig. 4. Second nymphal instar of *C. hyalinus*, × 29.
Fig. 5. Third nymphal instar of *C. hyalinus*, × 29.
Fig. 6. Fourth nymphal instar of *C. hyalinus*, × 29.
Fig. 7. Fifth nymphal instar of *C. hyalinus*, × 29.
Fig. 8. Adult female *C. hyalinus*, × 29.
Fig. 9. Egg of *C. lateralis*, lateral view, × 58.
Fig. 10. Egg of *C. lateralis*, viewed from above, × 58.

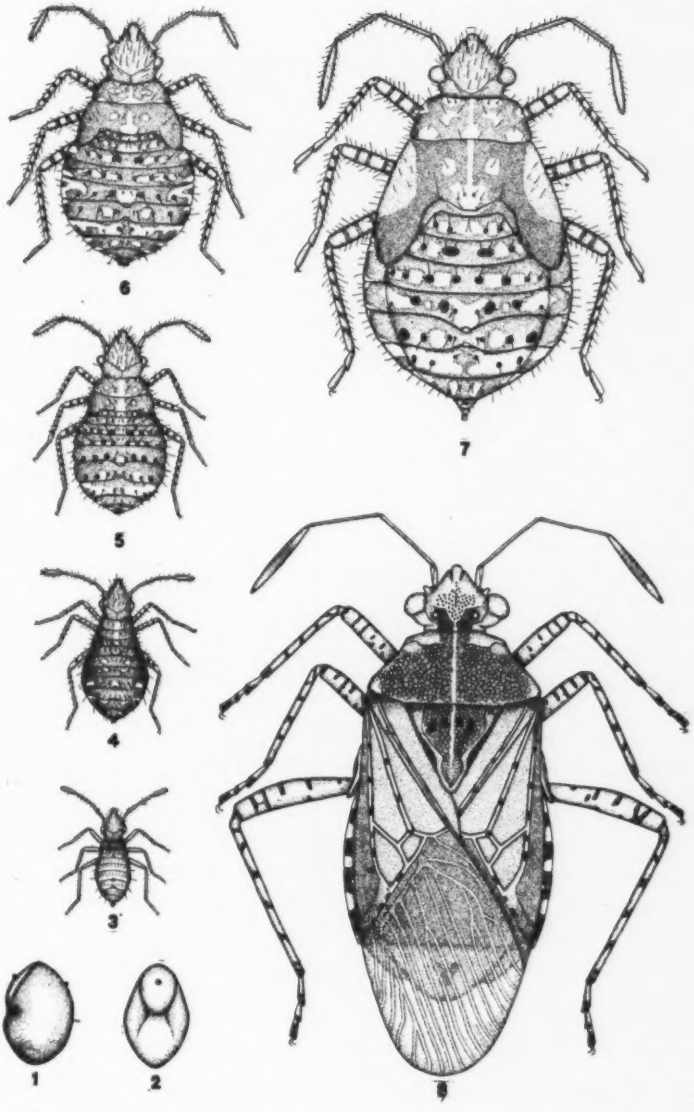
PLATE XI.

Corizus sidæ.

Fig. 1. Egg, lateral view, × 58.
Fig. 2. Egg, viewed from above, × 58.
Fig. 3. First nymphal instar, × 29.
Fig. 4. Second nymphal instar, × 29.
Fig. 5. Third nymphal instar, × 29.
Fig. 6. Fourth nymphal instar, × 29.
Fig. 7. Fifth nymphal instar, × 29.
Fig. 8. Adult female, × 29.



P. A. Readio



P. A. Readio

NOTE ON THE CULTIVATION OF METARRHIZIUM ANISOPLIÆ (METSCH.) SOROKIN FROM THE VEGETATIVE FORM IN SILKWORMS.*

R. W. GLASER.

In 1926, the writer[1] published an account of the green muscardine disease in silkworms caused by the fungus *Metarrhizium anisopliæ*. Among other matters, it was stated that one must start with spores to obtain development of the fungus on artificial media. "Media inoculated with the non-fruiting forms from larval blood always remained sterile. This is curious in view of the fact that fungus development will progress normally when these forms found in diseased cases are injected into the body cavity of normal worms by means of a syringe."

Since 1926 we have upon numerous occasions attempted to start cultures with the vegetative forms of *Metarrhizium anisopliæ* from the blood of diseased worms. Only one positive culture on nutrient agar was obtained out of four dozen trials and this was probably due to the fact that a considerable amount of blood was carried over with the inoculum. This method, however, subsequently proved rather unreliable, and therefore a more dependable one had to be devised. This was accomplished by flooding the surface of each sterile nutrient agar tube with $\frac{1}{10}$ cc. of diluted silkworm juice prepared according to the method described in 1926[2] for the cultivation of *Herpetomonas muscæ-domesticæ*. The prolegs of fungus infected silkworms were washed with and also dipped in 80 per cent alcohol. This was burned off, and blood obtained by pricking the prolegs with "minuten" needles.[3] The blood, containing the vegetative forms of the fungus, was then smeared over the surface of the media. In this way over 50 per cent cultures of *Metarrhizium* were obtained when the tubes were held at room temperature. Characteristic colonies developed in about four or five days and produced the olive green spores in a few more days.

LITERATURE CITED.

1. **Glaser, R. W.** The Green muscardine in silkworms and its control. Annals Ent. Soc. America, 1926, XIX, No. 2.
2. **Glaser, R. W.** Isolation and Cultivation of Herpetomonas muscae-domesticae. Am. J. Trop. Med., 1926, VI, 207.
3. The commercial name of very small needles obtained from entomological supply houses.

*From the Department of Animal Pathology of The Rockefeller Institute for Medical Research, Princeton, N. J.

PSELAPHIDÆ COLLECTED BY DR. ALFONS DAMPF IN CENTRAL AMERICA.

By Frank C. Fletcher,
Cornell University.

The material upon which this paper is based comprises collections of the Coleopterous family *Pselaphidæ* made by Dr. Alfons Dampf, Chief Entomologist, Mexican Department of Agriculture, in various Central American countries. Dr. Dampf very kindly placed these collections in my hands for study and furnished with them very complete data which I have incorporated almost without change.

Our knowledge of the *Pselaphidæ* of the tropics is yet very meager, and judging by this and several other collections, in which a very large proportion if not all of the contained species are undescribed, we have just made a beginning in the description of the numerous tropical forms, and in the mapping of their distribution. An attempt therefore, to draw conclusions of worth concerning the distribution of this family in the tropics, is yet premature.

At the request of Dr. Dampf, the holotypes of the species described in this paper have been deposited in the collection of Cornell University, and paratypes will eventually be placed in the U. S. National Museum.

The illustrations accompanying this paper have been drawn from appendages mounted in balsam, and it should be borne in mind that they have not been drawn to the same scale.

Eurhexius macrodactylus sp. nov.
(Plate XII, Figs. 5, 25).

Form elongate, subdepressed, slightly narrowed anteriorly; dark testaceous, antennæ, palpi, and legs paler; punctate-granulate, shining; pubescence rather dense, pale, and recumbent.

Head transverse, slightly narrower than prothorax; eyes very small, oval, not prominent; front very convex, head immediately behind depressed; vertex with two small but deep foveæ at the same distance from the median line as the antennal tubercles, connected by a well-defined horse-shoe shaped sulcus not defined anteriorly in the general depression; a small, but deep punctiform fovea on either side immediately behind the antennal tubercle and in line with the foveæ of the vertex; occiput and most of vertex convex, the former emarginate,

with a sulcus passing anteriorly to just beyond the line of the foveæ of vertex; sulci behind antennal tubercles deep. Antennæ slender, reaching slightly beyond middle of prothorax; basal segment elongate, cylindrical, second subquadrate broader than any of the six succeeding segments, third obconic, fourth to eighth transverse, subequal, nine larger, nine and ten transverse, eleventh squarely truncate at base, acutely pointed at apex, nine to eleven forming a distinct club; surface coarsely and rather roughly punctate; undersurface densely clothed with capitate hairs.

Prothorax as long as broad, narrowed at apex, widest at middle with the sides strongly arcuate; surface moderately convex, with two very deep, broad foveæ slightly prolonged anteriorly; these connected by a transverse sulcus which is crossed by a longitudinal sulcus extending from base to near apex; granulate-punctate, shining.

Elytra one-fifth broader than long; sutural stria fine, entire, discal reaching to about middle; base of each elytron with four foveæ; post-humeral fovea present, with the carina strong, extending to apex; finely aciculately punctulate, with rather dense recurved pubescence.

Abdomen slightly longer than elytra, gradually narrowed to blunt apex, strongly margined; dorsal segments subequal; first ventral very short, overlapped by posterior coxæ, second to fourth subequal, evenly convex, five broadly emarginate, six transverse.

Metasternum convex, slightly impressed at middle posteriorly.

Legs slender; anterior coxæ contiguous, middle slightly separated, posterior subcontiguous; anterior femora larger than the others, with a fine but sharp carina on lower face, posterior femora very slender; tibiæ scarcely arcuate; tarsi with two claws, the smaller thick, just less than half the length of the larger, the latter very large, dilated at tip.

Length 1 1⅛ mm., breadth ⅜ mm.

Holotype: April 26, 1925, collected S. W. of Mexico City, Mexico, on a mountain range called Desierto de los Leones, 3,000 M., in rotten trunk in *Abies religiosa* forest; (Cornell U., type No. 806). Paratypes: 2, March 25, 1925, in same region at 3,200 M. in rotten trunk of *Abies religiosa*; U. S. N. M. coll. and that of author).

This species is placed in *Eurhexius* because of its resemblance to *vestitus*, *parviceps*, *ventralis*, *trimioides* of Sharp and *rugulosus* Reitter. No indication is given by either author in their descriptions (or in the figure of *vestitus*) of prothoracic denticulations or teeth. Since Sharp based his genus *Eurhexius* upon the four species above mentioned, the genus must contain some species at least without denticulations, notwithstanding the fact that Raffray distinguished it from Casey's *Rhexidius* on the presence of denticles or teeth in the former. It is

extremely doubtful if the two genera *Eurhexius* and *Rhexidius* can be maintained as distinct, in which case *Eurhexius* has priority since it appeared in April while *Rhexidius* did not appear until August, 1887.

Macrodactylus is related to the three species *vestitus*, *parviceps*, and *ventralis*, but differs from them in the much longer last antennal segment which here is as long as the four preceding together, number of elytral foveæ, foveæ of head, etc. The enlarged claw of *macrodactylus* is noteworthy, but I do not know how widespread this condition is in the genus. The cephalic arcuate sulcus varies considerably in the three specimens before me, in one it is well-defined, in another it is much less distinct, while in the third it is entirely lacking. No other differences could be observed. The sex of the specimens is doubtful, I am inclined to believe that they are males.

Allobrox gen. nov. (Trichonychini).

Genotype: *Allobrox dampfi* sp. nov.

Head with two spongiose foveæ connected by an arcuate sulcus; antennæ widely separated at base, first two segments large, second ovate, third to seventh obconic, eight to ten very transverse, eleventh very large, equal in length to the five preceding together; undersurface with a blunt carina on middle line, foveate at base and clothed with capitate setæ; palpi short, first segment short, second strongly clavate, third as broad as long, subtriangular, fourth subfusiform, slightly more than three times longer than the preceding; a well-delineated though scarcely sulcate palpal sulcus present.

Prothorax with a large, deep, spongiose fovea on either side near margin, these connected by a deep transverse sulcus, which is continued to base at the middle.

Elytra with deep sutural striæ, discal striæ represented only by an elongate depression at base; base of each elytron with two large, deep foveæ, and a posthumeral fovea from which runs a very fine sulcus to apex.

Abdomen strongly margined, sides modified as described below; first dorsal segment as long as the next two, the remainder gradually decreasing in length; first ventral very short, hardly visible behind the coxæ, second very large, third deeply emarginate, sixth emarginate, seventh in the form of a circular operculum.

Legs moderately long, slender, unmodified; coxæ all contiguous, posterior coxæ conical; first tarsal segment minute, second a little less than twice longer than third and twice thicker at its broadest part, third with two very unequal claws, the smaller slightly arcuate, and about one-half as long as the larger.

Allobrox dampfi sp. nov.
(Plate XII, Figs. 20, 23).

♂. Elongate, subdepressed; body uniform testaceous, antennæ, palpi, and legs yellow; clothed with very fine, sericeous pubescence, shining.

Head including eyes, slightly narrower than prothorax, slightly broader than long, strongly narrowed anteriorly; eyes well-developed, convex, prominent; vertex and occiput very convex with two deep foveæ behind the middle line of the eyes, these connected by a well-marked arcuate sulcus; frontal tubercles not at all prominent; front evenly declivitous; labrum very large, quadrate. Antennæ reaching middle of prothorax, funicle slender; first and second segments large, about equal, second broader than any of the next six, three to six obconic, subequal, seventh broader, subglobular, eight to ten very transverse, eleventh large, elongate-oval, as long as the five preceding together, regularly and bluntly pointed at apex, club almost entirely formed by last segment.

Prothorax cordate, as broad as long; disk anteriorly very convex; a deep spongiose fovea on either side, connected by a sulcus from which a median sulcus runs to base.

Elytra slightly transverse, in their widest part three-sevenths broader than prothorax; base of each elytron with two deep foveæ, from the inner of which arises the very deep and entire sutural stria and from the outer the discal stria, represented only by a vague, elongate depression; a spongiose posthumeral fovea present, from which arises a very fine sulcus attaining apex; minutely and inconspicuously punctulate.

Abdomen subequal in length to the elytra, rapidly narrowed from base to apex; sides of first three segments very strongly and broadly margined, the inner carinæ strongly converging posteriorly; intercarinal interval of each side of first segment deeply concave, shining; interval of second segment likewise concave, the sides of the third ventral passing upwards in the form of an apically fimbriate, rounded lobe, and clasping the posterior lower angle of the segment; inserted immediately above this lobe in a slight depression of the segment is a small tuft of scales; first ventral very short, second very large, as long as the remaining together, two to three prominent laterally, third deeply and broadly emarginate, the remainder very small, sixth emarginate, seventh in the form of a rounded operculum.

Metasternum convex, slightly depressed along the middle.

Legs of moderate length, entirely unmodified.

Length 1 mm., breadth ⅝ mm. (at sides of abdomen).

Holotype: ♂, March 29, 1925, collected S. W. of Mexico City, Mexico on a mountainous range called Desierto de los Leones 3,200 M. altitude, from a rotten trunk of *Abies religiosa*; (Cornell U., type No. 805). Paratypes: 2 ♂ ♂ same data as holotype; (U. S. N. M., and author's collections).

Allobrox is without doubt more closely allied to the Chilian *Faronoma* than to any other of the *Trichonychini*. These two genera are alone in the tribe in possessing modifications of the dorsal abdominal segments reminding one of *Brachygluta*. *Allobrox* however is very different in the greatly enlarged terminal segment of the antennæ, only two prothoracic foveæ and no median sulcus, non-carinate prosternum, strong sub-marginal sulcus of elytra, presence of a well delineated, though not deep palpal sulcus, differences in abdominal sculpture, etc.

Scalenarthrus concavus sp. nov.
(Plate XII, Fig. 3).

♂. Subovate, very convex; rufo-testaceous throughout; subimpunctate, shining; pubescence short, very fine, sparse, and appressed.

Head quadrate, width including eyes slightly less than prothorax; eyes convex, prominent, coarsely faceted; surface subconvex, with a very small fovea on either side slightly behind inter ocular line; anteriorly with a strong transverse sulcus of even depth throughout, taking its origin from the post-antennal sulci on either side. Antennæ slender, reaching almost to base of prothorax; second segment elongate, cylindrical, broader than any of the succeeding six, third cylindrical, narrower and slightly shorter than fourth or sixth, nine to ten very transverse, eleven elongate-oval, sinuate internally at apex, and slightly longer than the four preceding together.

Prothorax very slightly broader than long, sides broadest in front of middle, rapidly and strongly rounded to apex, almost straight to base; disk very convex, without sculpture, shining.

Elytra quadrate, strongly convex, with very fine entire sutural striæ; extreme base carinated; four extremely feeble and minute impressions, the sutural being particularly ill-defined, at base of each elytron.

Abdomen five-eighths as long as elytra, convex, very obtuse; first dorsal segment without traces of basal carinæ, sides very finely, but distinctly margined; undersurface of all the segments broadly concave, sixth with a transverse plate of which the edges are free, and occupying entire segmental width.

Metasternum broadly concave.

Legs of usual length, unmodified.

Length 1 mm., breadth ⅓ mm.

Holotype: ♂, October 14, 1925, at light in virgin forest, Blue Creek, Orange Walk district, on the Rio Azul, boundary between Quintana Roo and the English colony, British Honduras; (Cornell U., Type No. 807). Paratypes: 2 ♂♂, same data as holotype (collections of U. S. N. M. and author). 1 ♂ December 14, 1925, at light in virgin forest near a place called Buena Esperanza, N. W. from Lake Peten, Guatemala (author's collection).

Concavus is related to the three described species making up Raffray's group II, from all of which it is easily known by the impunctate pronotal base, frontal sulcus of even depth, simple first ventral segment, squarely truncate base of last antennal segment, etc.

Scalenarthrus ventricosus sp. nov.
(Plate XII, Fig. 1).

♂. Subovate, ventricose; rather dark testaceous throughout; subimpunctate, shining; pubescence very short, fine and appressed.

Head quadrate, width including eyes equal to that of the prothorax; eyes large, convex, and prominent; surface slightly convex, with a small but deep fovea on either side slightly behind the middle of the eyes; foveæ connected by a feeble arcuate sulcus meeting a transverse frontal sulcus of even depth; antennæ almost reaching base of prothorax, rather stout; second segment elongate, cylindrical, third slightly obconic, four to ten transverse, very gradually increasing in width, nine and ten very transverse and oblique, eleven very large, squarely truncate at base, and obliquely pointed at apex; eleventh sinuate within at apex, surface with a large impression in basal half, the basal margin of which is sharp and the anterior indistinct; depression provided with a long, dense tuft of inward pointing pubescence on inner basal angle, appearing in certain lights as a tooth.

Prothorax transverse, one-fifth broader than long, broadest at middle, rapidly rounded to apex, more gradually and slightly sinuate to base, surface very convex.

Elytra ventricose, transverse, one-fourth broader than long; sutural stria fine but distinct to apex; extreme base slightly carinated, base of each elytron with four scarcely impressed foveæ.

Abdomen subequal in length to the elytra, regularly rounded to blunt apex; first dorsal slightly longer than any of the succeeding, provided at base with a pair of fine, slightly divergent carinæ, occupying one-fifth of the segmental width and extending one-third of the segmental length; undersurface evenly convex, without modifications of any kind.

Metasternum convex.

Legs slender and simple, hind tibiæ arcuate at apex.

Length 1 mm., breadth ⅝ mm.

Holotype: ♂, October 14, 1925 at light, near Blue Creek, Orange Walk district, on the Rio Azul, boundary between Quintana Roo and the English colony, British Honduras. (Cornell U., Type No. 809).

Ventricosus is related to *denticornis* Schaufuss of group IV, likewise provided with an arcuate sulcus on the head, but differs most strikingly in having the terminal antennal segment only slightly emarginate, and lacking any teeth.

Scalenarthrus globosus sp. nov.
(Plate XII, Fig. 2).

♂. Subovate, very convex, dark testaceous, shining; subimpunctate; pubescence very fine, short, and appressed.

Head quadrate, width including eyes, very slightly less than that of prothorax; surface almost flat, with a rather shallow fovea on either side behind the middle line of the eyes; anteriorly with a transverse sulcus of even depth; eyes large, convex and prominent; antennæ reaching the base of prothorax, funicle slender; second segment elongate, cylindrical, broader than any of the succeeding five, third obconic, only slightly transverse, four to seven more transverse, subequal in width, eight to eleven rather abruptly broader to form the club, eight to ten very tranverse, more or less oblique at apex, the latter provided internally at apex, with a blunt tooth which almost reaches the excavation of the eleventh, the tooth with a pair of long setæ at apex; eleventh longer than the four preceding together, expanded at basal half internally, sinuate below and very obliquely pointed at apex; surface with a deep, transverse excavation occupying part of basal half, which has on its basal margin at the outer edge a blunt tooth with a dense comb of setæ.

Prothorax transverse, broadest slightly before the middle, rapidly rounded to apex, almost straight to base, very slightly sinuate near hind angles; surface convex.

Elytra transverse, very convex, with a fine, entire sutural stria; extreme base carinate, each elytron having four scarcely impressed basal foveæ.

Abdomen slightly shorter than elytra; first dorsal longer than any of the others with fine but sharp basal carinæ, enclosing about one-fifth of the segmental width and extending one-third of the length of the segment; undersurface evenly convex without modifications of any kind.

Metasternum convex.

Legs normal, posterior tibiæ slightly thickened and arcuate towards apex.

Length 1 mm., breadth ⅝ mm.

Holotype: ♂, November 14, 1925, at light near San Francisco, Lake Peten, Guatemala. (Cornell U., Type No. 808). Paratype: 1 ♂, October 14, 1925, at light, Blue Creek, Orange Walk district, on the Rio Azul, boundary between Quintana Roo and the English colony, British Honduras; (author's collection).

Globosus belongs to Raffray's group IV, from all members of which group it is easily recognized by the lack of a cephalic arcuate sulcus, impression of last antennal segment not extending beyond basal half and the large tooth of the penultimate.

Scalenarthrus inflatus sp. nov.
(Plate XII, Fig. 4).

♂. Subovate, ventricose, rufo-castaneous throughout.

Head quadrate, including eyes equal in width to prothorax; vertex convex, with a well-marked fovea on either side slightly posterior to the middle line of the eyes, the foveæ united by an extremely feeble, and ill-defined arcuate sulcus; front with a sharply impressed transverse sulcus of even depth; surface subimpunctate; antennæ almost reaching base of prothorax, funicle rather slender; second segment cylindrical, longer than broad, broader than the next five, third obconic equal in width to next, four to six strongly transverse, about equal in width, seven very slightly wider, eight to eleven gradually broader to form a well-marked club, eight to ten very transverse, nine to ten almost lenticular, the latter with a strong tooth slightly overlapping eleventh, this very broad and almost as long as the six preceding segments; rather deeply excavated below apex and obtusely pointed, produced into a tooth on outer basal angle, which slightly overlaps the penultimate; entire surface, except for an area in inner apical angle, deeply excavated, the inner edge below this unexcavated area produced into a tooth as long as the width of the unexcavated area; surface behind middle of segment much more deeply excavated than apically.

Prothorax cordate, one-sixth broader than long, sides very slightly sinuate to base, more rapidly rounded to apex; a very small and inconspicuous punctiform impression at base; surface subimpunctate, sparsely clothed with fine recumbent pubescence.

Elytra ventricose, one-tenth broader than long; sutural stria fine and entire, discal completely wanting; extreme base margined, with four almost unimpressed foveæ on either side.

Abdomen convex, shorter than elytra, sides regularly arcuate to blunt apex; first dorsal segment a little longer than any of the following, at base with two very fine, sub-parallel carinæ reaching middle and occupying one-fourth of the segmental width; pygidium large and strongly deflexed; undersurface evenly convex, unmodified.

Metasternum convex.

Legs normal, hind tibiæ slightly arcuate in apical half.

Length 1 ⅕ mm., breadth ⅗ mm.

Holotype: ♂, December 19, 1926, Vera Cruz, Ver., Mexico, at light. (Cornell U., Type No. 810).

Inflatus is a member of Raffray's group IV, characterized by the more or less abnormal terminal antennal segment of the male. It is most closely related to *denticornis* Schaufuss and *cavicornis* Raffray, from the former it is easily recognized by the obtuse apex of the terminal antennal segment, with a much larger excavation, and from the latter by the antennal excavation covering most of the surface of the segment

Drasinus hirsutus sp. nov.
(Plate XII, Figs. 8, 24).

♂. Oblong-oval rufo-testaceous, legs and outer antennal segments slightly paler; subimpunctate, shining; pubescence rather long, dense, and recurved.

Head subquadrate, width including eyes slightly less than prothorax; eyes large and prominent; vertex slightly convex, with two deep, but poorly-limited foveæ very close to eyes and on their middle line; antennal tubercles prominent, post-antennal sulci very deep and well-marked, passing inward to slightly beyond the line of the vertexal foveæ; front between the tubercles depressed, with a minute, though deep fovea on either side immediately within each tubercle; subimpunctate, slightly rugose on epistoma; antennæ passing beyond base of elytra, rather slender, ten-segmented; second segment quadrate, three to six subequal in width, seven to eight slightly broader, third longer than broad, narrowed at base, fourth slightly shorter, seven somewhat transverse, eight subquadrate, subequal to preceding in width, nine slightly transverse, ten ovate, squarely truncate at base, apex rather acute; undersurface of head strongly tricarinate, the middle carina enclosing apically a very minute though distinct, elongate fovea; first segment of palpus minute, second elongate, strongly clavate, particularly externally, third subtriangular, longer than broad, rounded externally, acute internally, fourth longer than the others together, elongate oval, internally almost straight, externally rounded, especially at apical one-fourth, base obliquely truncate, apex blunt, terminal appendage long.

Prothorax transverse, broadest slightly in front of middle, feebly rounded to base and apex; disk evenly convex, with a large, deep fovea on either side and a smaller one at middle of base; general surface scarcely evidently punctulate, base with a row of deep coarse punctures; pubescence consisting of long, scattered hairs.

Elytra one-fifth broader than long, two-fifths broader than prothorax, broadest at about the middle, regularly rounded to base and apex; disk with deep, entire sutural striæ and two well-marked, parallel discal striæ reaching to middle; all striæ having their origin in basal foveæ; subimpunctate.

Abdomen three-fourths as long as elytra, sides of first segment parallel, then rapidly narrowed to blunt apex; first dorsal longer than the others, provided at its base with two parallel carinæ reaching middle and including at base almost one-half of segmental width; undersurface evenly convex, second segment greatly elongated, third slightly arched above fourth, which last is provided with a swelling with a fringe of white setæ, but is entirely hidden from above by the third segment and only visible when the insect is viewed from the rear; sixth segment broadly lobed to fit in the emargination of last dorsal.

Metasternum convex, prominent near the middle coxæ, in the form of an oblong, flat protuberance, covered with scales; posteriorly the metasternum is sulcate.

Legs slender, middle and hind tibiæ slightly arcuate apically.

Length 1 ½ mm., breadth ⅝ mm.

♀ similar to the male, but lacking the modifications of third and fourth segments, last segment scarcely at all lobed.

Holotype: ♂, December 19, 1926, Vera Cruz, Ver., Mexico. at light; (Cornell U., Type No. 811.1). Allotopotype: ♀, same data; (Cornell U., Type No. 811.2). Paratypes: 5 ♂♂, 2 ♀♀, same data as holotype; (collections of U. S. N. M., A. Dampf, and author); 1 ♂, December 13, 1925, at light, Blue Creek, Orange Walk district, on the Rio Azul, boundary between Quintana Roo and the English colony, British Honduras; (author's collection); 1 ♂, same place, at light, December 14, 1925; (author's collection).

It is with considerable hesitancy that I am describing the above insect as congeneric with *Drasinus nodicornis* Raffr. Unfortunately I have no representative of the latter at hand, but *hirsutus* agrees with the description of it in the strongly tricarinate undersurface of head, the raised oblong space of the metasternum, punctured base of prothorax, etc. The last palpal segment is very different, though formed on the same plan, and *nodicornis* is described as lacking a terminal appendage to this segment, which however is very prominent in *hirsutus*. In *hirsutus* there is no transverse frontal sulcus, but only two punctiform foveæ immediately within the antennal tubercles. The apical part of the epistoma in *hirsutus* is densely and rugosely punctate, no mention of which character is made in the description of *nodicornis*. In *hirsutus* the median carina of the ventral surface of the head is split anteriorly thus inclosing a small, elongate fovea, but not at all like the fovea of *Decarthron* which is very large. I do not know if this is the case with *nodicornis*, it being described as lacking a fovea. This fovea is very small and easily overlooked. In spite of the tricarinate undersurface of the head, and different fourth palpal segment, *Drasinus* has affinities decidedly in the direction of *Decarthron*, in the proximity of which genus I believe it should be placed.

Reichenbachia latipes sp. nov.

(Plate XII, Fig. 9, 29).

♂. Elongate-oval; testaceous throughout; pubescence short and recumbent, shining.

Head elongate, very slightly narrowed anteriorly, including eyes slightly narrower than prothorax; eyes convex, prominent; occiput

and vertex slightly convex; two deep pubescent foveæ slightly posterior to the middle line of the eyes, and a third deep fovea in a depression between the antennal tubercles; mandibles each provided with an acute tooth on outer side; antennæ slender, reaching beyond base of prothorax, second segment cylindrical, longer than broad, broader than the next five, third a little longer than fourth, both subcylindrical, five and six cylindrical, equal in length, fifth a little less than two times longer than broad, sixth twice longer than broad, eight subtransverse, shorter than seven or nine, nine and ten of same form, gradually broader and longer, eleventh oval, squarely truncate at base, obliquely pointed at apex, as long as the two preceding together, the last three segments forming a fairly distinct club.

Prothorax slightly broader than long, broadest in front of middle, arcuate to apex, almost straight to base; disk imperceptably punctulate, with two large pubescent foveæ at the sides and a small punctiform one at middle of base.

Elytra transverse; disk convex, very finely and indistinctly punctulate; sutural striæ deep and entire, discal deep, five-sixths as long as elytra, convergent.

Abdomen equal in length to the elytra; first segment about twice as long as second, basal carinæ feebly developed, divergent, not reaching basal fourth, occupying at base a little less than one-third of the width of the first segment; surface of dorsal segments densely, but rather indistinctly punctulate; ventral segments lightly depressed along the middle line, sixth slightly lobed at apex, coarsely punctured.

Metasternum broadly concave.

Legs slender, middle femora larger than either the anterior or posterior; posterior tibiæ strongly dilated externally, at the middle with an elongate depression on under side.

Length 1 ⅜ mm., breadth ½ mm.

♀. Similar to the male, differing in the lack of a tooth on the outer side of the mandible, structure of the antenna which has the second segment elongate, cylindrical, broader than the next five, three to seven elongate, but narrower, third very slightly obconic, fourth shorter, five and six each twice longer than third, seven cylindrical, shorter than preceding, eight subtransverse, broader than preceding, nine to ten subquadrate, larger, eleven elongate-oval, obtusely pointed, as long as the three preceding; metasternum very slightly depressed; ventral segments evenly convex; middle femora of same size as the others, hind tibiæ simple.

Holotype: ♂, December 19, 1926, Vera Cruz, Ver., Mexico, at light; (Cornell U., Type No. 815.1). Allotopotype: ♀, same data; (Cornell U., Type No. 815.2). Paratypes: 3 ♂♂, 9 ♀♀, same data; (collections of U. S. N. M., A. Dampf, and author).

By Raffray's table this species would run to group XLVII because of the swollen hind tibæ. *Latipes* probably should

form another group, because of it's dentate mandibles and antennal structure, for aside from the enlarged tibiæ it does not seem very closely allied to any of the described species.

Reichenbachia guatemalensis sp. nov.
(Plate XII, Fig 6).

♂. Elongate-oval; rufo-testaceous throughout; minutely and inconspicuously punctulate; pubescence fine, sericeous.

Head longer than broad, narrowed anteriorly, including eyes almost equal in width to prothorax; vertex convex, with two large, deep pubescent foveæ between the eyes, a third similar fovea on the front; mandibles externally each with an obtuse tooth; punctuation very fine and inconspicuous; antennæ slender, reaching beyond base of prothorax, with a feeble three-segmented club; second segment elongate, cylindrical, third obconic subequal in length to preceding, three and four narrower than preceding, five as long as the two preceding together, six to eight increasingly shorter, eight equal in width to immediate preceding, transverse, slightly prominent at basal internal angle, 9 subquadrate, broader, ten of same form larger, eleven oval, squarely truncate at base, obliquely pointed at apex.

Prothorax quadrate, widest in front of middle, almost straight to base, and broadly rounded to apex; surface convex, with a large, deep, pubescent fovea on either side behind the middle, and a very small punctiform one in the middle near base; surface shining, very minutely punctulate, and clothed with very fine, short decumbent pubescence.

Elytra transverse; disk with distinct sutural striæ, and two very convergent discal striæ reaching apical one-fifth; base of each elytron with three foveæ; pubescence very short, dense, and recumbent.

Abdomen three-fifths as long as elytra; sides of first segment parallel, then rapidly narrowed to blunt apex; base of first segment with two parallel carinæ reaching one-fourth of segmental length and including at base slightly over one-third of the entire segmental width; first ventral just perceptably flattened at middle, last segment broadly emarginate to receive lobe of pygidium.

Metasternum concave.

Legs of usual length; hind tibiæ slightly arcuate, strongly swollen at apex to over twice the width at base.

Length 1 ⅖mm., breadth ⅕ mm.

♀. In all respects similar to the male, except that the mandibles are simple, metasternum only slightly concave, hind tibiæ simple, antennæ normal, having the second segment cylindrical, longer than broad, three to eight subequal in width, third equal in length to preceding, slightly obconic, four to seven very slightly obconic, fourth shorter than either third or fifth, five to eight decreasing in length, eight slightly transverse, nine to eleven very gradually enlarged to form a three-segmented club, which is not at all distinct.

Holotype: ♂, November 14, 1925, at light near a place called San Francisco, Lake Peten, Guatemala; (Cornell U., Type No. 812). Allotype: ♀, December 12, 1925, at light in virgin forest near a place called San Miguel, N. W. from Lake Peten, Guatemala; (author's collection). Paratype: 1 ♂, same data as holotype; (author's collection).

Guatemalensis apparently does not enter any of the groups proposed by Raffray, because of the modified fifth and sixth segments of the antennæ and not compressed though dilated hind tibiæ of the male. It seems to come near the species of group XLVII containing Nearctic species, but is easily known by the toothed mandibles, antennal structure, and the dilated hind tibiæ of the male.

Reichenbachia carinifer sp. nov.
(Plate XII, Fig. 7).

♂. Oblong, testaceous throughout; indistinctly punctured, shining; pubescence very short, sericeous.

Head longer than broad, slightly narrowed anteriorly; mandibles each with an acute tooth on outer side; eyes large prominent; vertex on median line strongly and sharply carinate posteriorly, the carina continued anteriorly as an obtuse ridge; a deep punctiform fovea present on either side slightly behind the middle line of the eyes, and situated in a general depression; no frontal fovea; basal part of vertex and occiput behind the crest with a transverse, densely, but finely granulated area covered with long, yellow hair, pointing forward; antennæ long and slender, reaching beyond base of prothorax; second segment subquadrate, three and four both transverse, narrower than second, five greatly enlarged, broader and about three times longer than second, arcuate externally, armed internally near apex with a strong, very slightly anteriorly pointing spicule, enlarged at apex, six slightly longer than broad, seven shorter, narrower than six, eight subtransverse, nine and ten of same form, narrower at base, gradually larger, eleven elongate-oval, somewhat obliquely pointed at apex; club not distinct.

Prothorax broader than head across eyes, transverse, broadest in front of middle, from there almost straight to base; disk regularly convex with a large circular pubescent fovea on either side and a small punctiform one at middle near base; surface subimpunctate, clothed with recumbent pale hairs.

Elytra transverse, regularly convex, very minutely punctulate and with short recumbent pubescence; sutural striæ strong entire, discal deep, curved posteriorly, extending almost to apical one-fifth; base of each elytron with three distinct foveæ.

Abdomen slightly narrower than elytra; first segment about twice as long as second, carinæ separated at base by about one-third of

segmental width, divergent, extending one-half the length of the segment; ventral segments slightly flattened along median line, last concave and slightly lobed at apex to fit in the emargination of last dorsal.

Metasternum depressed along median line.

Legs unmodified, slender, hind tibiæ a little arcuate.

Length 1 ⅜ mm., breadth ⅓ mm.

♀. Resembling the male, except that the vertex is not sharply carinate, the vertex between the foveæ having an obtuse carina; mandibles simple; second segment of antenna quadrate, third narrower, obconic, fourth subcylindrical, equal to preceding in length, fifth elongate, cylindrical, as long as the two preceding together, sixth cylindrical, two-thirds as long as the preceding, seventh short, cylindrical, eight subtransverse, nine to eleven as in the male; ventral abdominal segments evenly convex; metasternum not depressed.

Holotype: ♂, December 19, 1926, at light, Vera Cruz, Ver., Mexico; (Cornell U., Type No. 813.1). Allotopotype: ♀, same data; (Cornell U., Type No. 813.2); Paratypes: 3 ♂♂, 4 ♀♀, same data; (collections of U. S. N. M., A. Dampf, and author).

A member of group LV, containing three described species from Madagascar, Sumatra, and Guatemala. From all of these *carinifer* is easily recognized by the carinate head of the male, and the structure of the antennal segments in the same sex.

Reichenbachia bifoveata sp. nov.

(Plate XII, Fig. 10).

♂. Elongate-oval, rufo-testaceous, legs paler; shining, not distinctly punctate; pubescence rather coarse, short, dense and suberect.

Head elongate, narrowed anteriorly; including eyes, narrower than prothorax; dorsal surface smooth, not perceptably punctate, with two large pubescent foveæ slightly behind the middle line of the eyes; antennal tubercles prominent; inter-antennal space slightly depressed, occipet very slightly convex; antennæ slender, reaching beyond base of prothorax; second segment cylindrical, longer than broad, three to seven elongate, subequal in width, third about twice longer than broad, narrower than preceding, four, five, and seven about equal in length, six slightly shorter, eight subquadrate, nine slightly produced internally, ten subglobular, eleven ovate, bluntly pointed at apex, nine to eleven very gradually wider to form a feebly differentiated club; mandibles simple.

Prothorax one-fourth broader than long, widest slightly before the middle, sides rounded to apex, almost straight to base; disk convex, not perceptably punctate, clothed with moderately long semi-erect pubescence; a large circular pubescent fovea on either side and a very minute one at middle near base.

Elytra one-sixth broader than long; surface convex, imperceptably punctate, clothed with erect, moderately dense, coarse pubescence; base of each elytron with two foveæ; discal stria almost reaching apical fourth, very strongly and broadly impressed at base, the two converging, sutural stria entire and strongly impressed throughout its entire length.

Abdomen about equal in length to the elytra, conical, sides of first and second segments parallel, then almost straight to the acute apex; basal carinæ strong, divergent, at base occupying a little over one-third of the total width of the first segment, and almost one-half its length; ventral segments somewhat depressed along median line, last deeply and broadly concave, strongly lobed at apex.

Metasternum broadly concave posteriorly.

Legs of usual length; middle trochanters armed with an indistinct acute tooth; hind tibiæ strongly arcuate, more strongly so in apical third.

Length 1 ⅜ mm., breadth ⅓ mm.

♀. Head similar, but foveæ larger; antennæ less slender, segments three to eight consequently shorter; abdomen convex, without modifications, not pointed at apex.

Holotype: ♂, December 19, 1926, Vera Cruz, Ver., Mexico, at light; (Cornell U., Type No. 814.1). Allotopotype: ♀, same data; (Cornell U., Type No. 814.2). Paratypes: 2 ♂♂, 4 ♀♀, same data; (U. S. N. M. collection and that of author).

A member of group LIV, and related to *celata* Sharp, from which and the others it is easily known by the size and shape of the antennal segments of male, distance between abdominal carinæ, head narrowed anteriorly, etc.

Decarthron fractifrons sp. nov.

(Plate XII, Fig. 11).

♂. Form elongate-oval; rufo-testaceous, legs and antennæ paler; pubescence short and recumbent; minutely and inconspicuously punctulate, shining.

Head from epistomal margin longer than broad, width including eyes slightly less than prothorax; vertex convex, with two punctiform foveæ between the eyes; front flattened, evenly declivitous, narrowed to a rounded point, free from the epistoma; front margin of epistoma raised into a vertical, transverse, triangular process rounded at tip which reaches the elevation of the front and almost touches it; surface minutely punctulate, and clothed with fine recumbent pubescence; antennæ passing base of elytra, with gradually-formed club; segment one with a broad, obtuse projection beneath, second subquadrate, three obconic, four and five oval, six and seven shorter, three to six equal in width, eight very slightly broader, transverse, nine transverse, slightly obconic, ten squarely truncate at base, narrower than ninth, ovate, with a rather acute tip.

Prothorax slightly transverse, broadest just in front of middle, sides feebly arcuate to apex and base; disk convex, with a deep pubescent fovea on either side and a smaller nude one at middle near base; surface shining, very minutely punctulate, clothed with fine recumbent pubescence.

Elytra transverse; sutural striæ deep and entire, discal fine but sharp, extending slightly beyond middle, converging behind; surface very finely and minutely punctulate, pubescence short, rather dense, and recurved.

Abdomen three-fifths as long as elytra; sides of first dorsal subparallel, then sides of abdomen rapidly narrowed to blunt apex; first dorsal with two slightly divergent carinæ at base, not reaching middle and enclosing at base almost one-half of the entire segmental width; first ventral just perceptably flattened, last broadly lobed at apex, the lobe fitting in emargination of last dorsal.

Metasternum with a broad, flat-bottomed longitudinal channel, the surface on either side convex.

Legs slender, middle trochanters with a fine comb of dense setæ at distal end; anterior femora just slightly less robust than middle or posterior femora; anterior tibiæ without spatulate spur, posterior arcuate in distal third.

Length 1 ⅜ mm., breadth ⅜ mm.

♀. In general similar to the male, differing in the simple epistoma which lacks process and is simply separated from the front by a well-marked transverse groove; first antennal segment without projection; more slender femora; evenly convex ventral segments, with the terminal not lobed; lack of comb of white hairs on middle trochanters.

Holotype: ♂, December 19, 1926, at light, Vera Cruz, Ver., Mexico; (Cornell U., Type No. 823.1). Allotopotype: ♀, same data; (Cornell U., Type No. 823.2). Paratypes: 7 ♂♂, 11 ♀♀, same data as holotype; (collections of U. S. N. M., A. Dampf, and author).

Due to the armed epistoma of the male, this species has affinities with those of group I, but on the other hand the front here is not at all squarely truncate, being narrowed and declivitous.

The protuberance on the undersurface of the first antennal segment varies considerably in the material before me. In the type it is distinct, but in other males it becomes less distinct, while in a few it is entirely wanting.

Decarthron squamosum sp. nov.
(Plate XII, Figs. 12, 27).

♂. Form elongate-oval; rufo-testaceous, legs and antennæ paler; pubescence fine and recurved; finely and inconspicuously punctulate, except on elytra where the punctures are denser and slightly more conspicuous, shining.

Head from epistomal margin longer than broad, width including eyes very slightly less than prothorax; two deep foveæ between the eyes, these joined by an almost imperceptable sulcus, visible only in certain lights; front depressed between antennal tubercles; occiput convex; post-antennal sulci very broad, pale yellow in color, conspicuous; antennæ just reaching base of elytra; second segment subquadrate, third obconic, four to six oval, subequal in width, six shorter than preceding, seven transverse, very obliquely truncate at apex, outer side produced, much larger than inner, eight and nine very transverse, eight narrower than seven, ten squarely truncate at base, oval, bluntly pointed at apex; club four-segmented.

Prothorax transverse, widest slightly before the middle, sides feebly curved; surface regularly convex, very shining; base with a single fovea, punctuation very minute and inconspicuous; pubescence rather sparse and recurved.

Elytra transverse; surface regularly convex, sutural striæ deep and entire, discal deep at base, disappearing at middle; punctuation very fine; pubescence, rather short, recurved.

Abdomen two-thirds as long as elytra; sides of first segment subparallel, then rapidly narrowed to obtuse apex; first dorsal subequal in length to the remaining together, provided at base with two divergent carinæ which extend half the length of the segment and include at base one-half of the segmental width; ventrally the abdomen is just perceptably flattened at base, last segment pointed, fitting into emargination of last dorsal.

Metasternum slightly concave, covered with a large dense patch of scale-like hairs.

Legs moderate in length; anterior femora more strongly clavate than the posterior; middle femora very greatly swollen, notched distally, the basal edge of emargination having a thin erect lamina provided with a comb of white scale-like hairs or setæ internally at base; anterior tibiæ slender, provided with a spatulate spur; middle tibiæ slender, with a dense brush of hairs at apex, posterior tibiæ arcuate.

Length 1 ⅗ mm., breadth ⅗ mm.

♀. Differs from the male in that the antennæ have the seventh segment not broader than eight, simply slightly transverse, not produced; the middle femora simple and unmodified, although thicker than the others; the anterior tibiæ without spatulate spur; lack of dense patch of scales on metasternum; base of abdomen convex ventrally.

Holotype: ♂, December 19, 1926, at light, Vera Cruz, Ver., Mexico; (Cornell U., Type No. 819.1). Allotopotype: ♀, same data; (Cornell U., Type No. 819.2). Paratypes: 50 ♂♂, 48 ♀♀, same data; (collection of Cornell U., U. S. N. M., A. Dampf, and author).

Due to the modified antennal segments of the male, *squamosum* must be placed in Group VI, among the described

species of which it resembles slightly *quadraticeps* Raffr., but is easily distinguished by the produced seventh segment of the male antenna, structure of the middle femur of the male, etc.

Decarthron rugulosum sp. nov.
(Plate XII, Fig. 13).

♂. Form elongate-oval; rufo-testaceous; minutely and inconspicuously punctulate, except on head, shining, pubescence long, pale, and recurved.

Head from epistomal margin longer than broad, width including eyes slightly less than prothorax; eyes large, convex, and prominent; surface on either side with a deep fovea on interocular line; area immediately about them broadly impressed, rendering the vertex along the median line obtusely carinate; occiput with a poorly marked short sulcus; epistoma continuous with the front, with a triangular flattened area, densely, coarsely, and rugosely punctate; antennæ short, not reaching base of elytra; first segment elongate, second quadrate, third broader than second, and any of the next four, obconic, internally produced, fourth of same form as preceding less produced internally, fifth and sixth subequal in width, both slightly produced within, seven transverse, a little wider than the preceding, oblique at apex, eight to ten gradually broader to form the club, eight and nine very transverse, ten as long as the two preceding together, obliquely pointed at apex.

Prothorax transverse, widest slightly in front of middle; surface very convex, the single basal fovea large; pubescence like that of the elytra; subimpunctate, shining.

Elytra transverse, one-sixth broader than long, slightly less than twice broader than prothorax; sutural striæ deep and entire, discal deep and well-defined, the two almost parallel and extending slightly beyond the middle; base of each elytron with two foveæ; surface not distinctly punctulate; pubescence moderate, rather coarse, and recumbent.

Abdomen somewhat shorter than elytra; sides of first segment parallel, then rapidly rounded to blunt apex; first dorsal a little more than twice the length of the second, the carinæ reaching middle and including at base one-half of the entire width of the segment; undersurface evenly convex, without modifications.

Metasternum broadly and longitudinally depressed; a few irridescent scales present in the sulcus posteriorly.

Legs of usual length; anterior tibiæ and femora very deeply and densely punctate on anterior face; spur of front tibia large and spatulate; middle femora a little more clavate than the anterior, and much more so than posterior, unmodified; hind tibiæ slightly arcuate distally.

Length 1 ⅗ mm., breadth ⅘ mm.

♀. Differs from the male as follows: epistoma entirely deprived of punctures, convex; antennæ similar except that segment three is regularly obconic, not produced, four not produced, of same form and size as fifth; depression of metasternum is less marked and without

scales; anterior femora without the dense conspicuous punctuation of the male, and subequal in size to the middle; anterior tibia without spatulate spur.

Holotype: ♂, December 19, 1926, Vera Cruz, Ver., Mexico, at light; (Cornell U., Type No. 817.1). Allotopotype: ♀, same data; (Cornell U., Type No. 817.2). Paratypes: 73 ♂♂, 73 ♀♀, same data; (collections of Cornell U., U. S. N. M., A. Dampf, and author).

Rugulosum is most closely related to *punctatum*, described hereafter and with it should be placed in group VI because of the modified antennæ of the male. *Rugulosum* differs, among other characters, by the punctate area of the epistoma being flattened and triangular which is not the case in *punctatum* where the punctate area is not set off, for the entire epistoma is evenly convex, and the shape and size of the antennal segments of the male. These two species are very isolated in the group, because of the simple middle femora of the male, and probably should form another group.

Decarthron punctatum sp. nov.
(Plate XII, Fig. 16).

♂. Form elongate-oval; dark rufo-testaceous; pubescence moderate in length, rather dense, recurved; hardly perceptably punctulate, shining.

Head from epistomal margin longer than broad, width including eyes slightly less than prothorax; surface almost flat, with two deep foveæ between the eyes, these connected by a shallow, irregular, and ill-defined arcuate sulcus which is more broadly impressed anteriorly; within and close to the antennal tubercles is a very small fovea on either side; occiput with a feeble impression; post-antennal sulci deep and well-defined; epistoma evenly continuous with the front, covered with large, deep, and conspicuous punctures, forming a somewhat rugose surface; antennæ stout, reaching base of elytra; club not distinct; second segment subquadrate, third elongate, longer than any except the last, obtusely prominent internally, fourth shorter, subglobular, slightly prominent internally, five to nine transverse, five evenly rounded externally, bluntly pointed internally, six to eight narrower than those on either side, very transverse, nine slightly broader, ten ovate, squarely truncate at base, bluntly pointed at apex; surface of segments covered with large, deep and conspicuous punctures.

Prothorax transverse, broadest slightly in front of middle, then feebly arcuate to base, more rapidly rounded to apex; disk evenly convex, base with a single deep fovea; minutely punctulate; pubescence long, scattered, and recumbent.

Elytra five-sixths as long as broad, widest at about the middle; surface evenly convex, sutural stria deep and entire, discal well-defined, almost straight, reaching slightly beyond the middle: surface imperceptably punctulate, with a few very shallow inpressioms scattered over the surface especially near the suture; pubescence rather dense, particularly on the sides, rather long and recurved.

Abdomen shorter than the elytra, sides of first dorsal almost parallel, then abdomen rapidly narrowed to blunt apex; first dorsal longer than the remaining together, with two slightly divergent carinæ extending a little beyond the middle, and at base including almost one-half of the segmental width; undersurface evenly convex, last segment somewhat impressed.

Metasternum lightly impressed along the middle.

Legs moderate in length, femora feebly clavate, posterior ones particularly so, none modified; anterior tibiæ with spatulate spurs, posterior tibiæ very slightly arcuate in distal half.

Length 1 ⅜ mm., breadth ⅝ mm.

Holotype: ♂, December 19, 1926, at light, Vera Cruz, Ver., Mexico; (Cornell U., Type No. 820). Paratypes: 5 ♂, same data; (collections of U. S. N. M., and author).

Allied to *rugulosum* and with it should be placed in group VI. It differs from it in the very large third to fifth antennal segments, different sculpture of head, epistoma not raised and flattened in a definite punctate area, etc.

In the six specimens before me the sculpture of the head varies somewhat, being flatter in some with the loss of the circumambient sulcus.

Specimens of this and *rugulosum* have been dissected to verify the sex.

All the females assigned to *rugulosum* are homogeneous, and it is impossible to find a single specimen among the numerous examples assigned to *rugulosum* referable to *punctatum*.

Decarthron quadrifoveatum sp. nov.
(Plate XII, Figs. 14, 31, 33).

♂. Form elongate-oval; dark rufo-testaceous; pubescence fine and recurved; shining.

Head from epistomal margin elongate, sides subparallel, across eyes about equal to prothorax in width; surface almost flat, with two deep foveæ on middle line of eyes, and anterior to which slightly closer together are two other foveæ, minute, though distinct; antennal tubercles not at all prominent, with a sharply defined sulcus behind them; surface subimpunctate, more densely and coarsely punctate on anterior margin of epistoma; antennæ reaching base of prothorax, contorted; second

segment subovate, third obconic, longer than wide, four to six subovate subequal in width, seven to nine transverse, seven obtusely and obliquely produced internally, eight broadly produced internally, oblique at apex, nine regularly transverse, ten ovate, squarely truncate at base, bluntly pointed at apex.

Prothorax slightly transverse, broadest a little before the middle, sides regularly arcuate to apex, almost straight to base; surface convex, with a large deep fovea at middle of base; very minutely punctulate, clothed with recumbent pubescence.

Elytra transverse, broadest slightly behind the middle; sutural striæ deep and entire, discal straight, reaching slightly beyond the middle; surface obsoletely and very minutely punctulate, clothed with scattered pubescence.

Abdomen a little shorter than elytra, sides of first segment parallel, then abruptly narrowed to blunt apex; first dorsal subequal in length to remaining segments together, provided at base with two divergent carinæ, not quite reaching middle, and including between their bases about one-half of the entire width of abdomen; undersurface regularly convex, last ventral transversely impressed in middle.

Metasternum longitudinally impressed.

Legs moderate in length, anterior and middle femora strongly clavate; anterior femora deeply emarginate dorsally, in outer half; middle femora deeply emarginate and concave, in outer half dorsally, basal and apical edges of emargination each with a truncate spine, that on the basal edge hollow; posterior femora slender; anterior tibiæ with spatulate spurs, posterior very slightly arcuate.

Length 1 ⅜ mm., breadth ⅓ mm.

Holotype: ♂, December 19, 1926, at light, Vera Cruz, Ver., Mexico; (Cornell U., Type No. 821).

Quadrifoveata is a member of group VI because of its modified antennæ and is distinguished from the other species by the produced seventh and eighth antennal segments, and the armature of the male femora.

Decarthron complicatum sp. nov.

(Plate XII, Fig. 17)

♂. Elongate-oval; rufo-testaceous, legs and antennæ slightly paler; minutely and inconspicuously punctulate, shining; pubescence rather dense and recumbent.

Head from epistomal margin longer than broad, slightly narrowed anteriorly; width including eyes slightly less than that of the prothorax; occiput and vertex convex, the latter with two deep foveæ between the eyes, these connected with a poorly-defined sulcus which is lost in the depression of the front; front between antennal tubercles depressed, with two inconspicuous foveæ close to one another; antennal tubercles prominent; epistoma strongly convex; pubescence sparse, denser, longer, and coarser on epistoma; antennæ reaching base of

elytra, rather slender, with a distinct three-segmented club; second segment subquadrate, third elongate-oval, four to six more or less globular, the latter two slightly oblique at apex, fourth broader than either third or fifth, five and six equal in width, seventh narrower than preceding, transverse, eight to ten enlarged to form a distinct club, eight to nine transverse, ten ovate, squarely truncate at base, apex rather acute.

Prothorax transverse, sides widest slightly in front of middle, then feebly arcuate to base, more so to apex; base with a single fovea; minutely and inconspicuously punculate; clothed with short, scattered pubescence.

Elytra transverse, one-fifth broader than long, two-fifths broader than prothorax; surface evenly convex, with deep entire sutural striæ, and well-marked discal striæ, which reach the middle; punctuation minute and very inconspicuous; pubescence fine and recumbent.

Abdomen three-fourths as long as the elytra, sides of first segment subparallel, then rapidly narrowed to blunt apex; first dorsal about as long as remaining together, with two divergent carinæ reaching middle, and enclosing between their bases almost one-half of the entire segmental width; undersurface evenly convex.

Metasternum concave, densely covered with hair-like scales.

Legs of usual length; anterior tibia with a spatulate spur; anterior and posterior femora slender, middle very greatly enlarged, deeply emarginate and impressed; basal edge of emargination prolonged into a tooth in same plane, apical margin is continued within the emargination on the outer edge by a transparent lamella; bottom of emargination provided with an oblique lamella not connected with the sides; middle trochanters obtusely angulate; posterior tibiæ arcuate.

Length 1 ⅛ mm., breadth ⅜ mm.

Holotype: ♂, December 12, 1925, at light, in virgin forest, N. W. from Lake Peten, near San Miguil, Guatemala; (Cornell U., Type No. 824).

Due to the enlarged fourth segment of antenna, this species must be referred to group VI, from any of the described species of that group it is at once distinguished by the armature of the middle femora, which here is more complicated than any I know of.

Decarthron denticulatum sp. nov.

(Plate XII, Figs. 18, 26, 30).

♂. Elongate-oval; uniform rufo-testaceous, legs slightly paler; surface shining, very finely punctulate; pubescence long, coarse, erect, and rather sparse.

Head from epistomal margin longer than broad, slightly narrowed anteriorly; across eyes about equal in width to prothorax; occiput slightly convex, vertex with two deep foveæ on the interocular line, these joined by a broad, and shallow arcuate sulcus which becomes very

faint anteriorly; antennal tubercles slightly prominent, sulci behind them deep and broad; sparsely clothed with long, coarse, semi-erect pubescence; antennæ rather stout, just passing base of elytra, with a feebly-differentiated three-segmented club; second segment quadrate, three obconic, longer than broad, four to seven subglobular, eight slightly transverse, broadly produced internally, ten squarely truncate at base, bluntly pointed at apex.

Prothorax transverse, broadest in front of middle, sides straight and oblique to base; disk evenly convex, sparsely and hardly visibly punctulate, clothed with long, erect, coarse pubescence; a single deep fovea in middle of base.

Elytra three-fourths as broad as long, twice as wide as prothorax, broadest at the middle, then in a regular curve to base; sutural striæ deep and entire, discal almost straight, reaching slightly beyond middle; subimpunctate; clothed with long, recurved pubescence.

Abdomen about equal in length to elytra; sides of first segment parallel at base then abdomen rapidly narrowed to blunt apex; first segment longer than the remaining together, with two divergent carinæ reaching middle and occupying almost one-half of segmental width; undersurface convex, last segment transversely impressed.

Metasternum convex, longitudinally impressed.

Legs short; anterior femora strongly clavate; middle femora greatly enlarged; above broadly and deeply emarginate, the basal edge armed with a truncate hollow spine, the apical edge with an incurved tooth, the greater part of the emargination occupied by a thin lamella; apex of middle femur strongly constricted; posterior tibiæ slightly arcuate.

Length 1 ⅝ mm., breadth ⅝ mm.

Holotype: ♂, December 19, 1926, at light, Vera Cruz, Ver., Mexico; (Cornell U., Type No. 822).

This is a member of group VIII related to *planiceps* Raffr. and *schmitti* Raffr., but is easily distinguished by the armature of the middle femora.

Decarthron tropicum sp. nov.

(Plate XII, Figs. 19, 28, 32).

♂. Elongate-oval; rufo-testaceous, legs slightly paler; minutely and inconspicuously punctulate; pubescence rather fine, recurved.

Head from epistomal margin longer than broad; width across eyes slightly less than that of prothorax; occiput convex, very lightly impressed, otherwise the surface of the head is flat, depressed between the antennal tubercles; two deep foveæ between the eyes; antennal tubercles prominent; post-antennal sulci very broad and deep giving the impression of a deep fovea behind each tubercle; antennæ stout, reaching base of elytra; second segment subquadrate, third slightly obconic, four to six longer than broad, more or less oval, three to six equal in width, seventh a little broader, subquadrate, eight and nine transverse, ten ovate, squarely truncate at base, bluntly pointed at apex.

Prothorax transverse, broadest slightly in front of middle, sides feebly arcuate to base, more rapidly to apex; surface evenly convex, with a deep fovea at base; subimpunctate; pubescence fine, short, and recumbent.

Elytra transverse, five-sixths as long as broad; sutural striæ entire, dorsal deep, parallel, reaching middle; scarcely perceptably punctulate; pubescence fine, recurved.

Abdomen shorter than elytra; first dorsal slightly longer than remaining together, at base with two divergent carinæ reaching middle and including almost one-half of segmental width, a distance equal to the maximum separation of the discal striæ; undersurface evenly convex, last ventral broadly lobed; extreme base of abdomen with a short carina.

Metasternum broadly concave, rather densely covered with silky pubescence.

Legs of usual length; anterior femora strongly clavate, with an oval, impressed, minutely granulate area dorsally in outer half; middle femora as strongly clavate as the anterior, with a rather deep, irregular depression in distal half dorsally; posterior femora feebly swollen; anterior tibiæ with a spatulate spur; middle tibiæ stout, slightly arcuate, with a dense brush of hairs distally; posterior tibiæ more slender, very slightly arcuate.

Length 1 ⅜ mm., breadth ⅜ mm.

♀. Differing chiefly in antennal segments four to six more or less globular, lack of a dilated spur on front tibiæ, simple anterior and middle femora, the latter being larger than anterior, and the scarcely impressed metasternum.

Holotype: ♂, December 19, 1926, at light, Vera Cruz, Ver., Mexico; (Cornell U., Type No. 816.1). Allotopotype: ♀, same data; (Cornell U., Type No. 816.2). Paratypes: 11 ♂♂, 6 ♀♀, same data; (collections of Cornell U., U. S. N. M., A. Dampf, and author).

Tropicum is apparently close to *fallaciosum* Sharp which is unknown to me, and there is a slight possibility that the two may be one species. However *tropicum* has segments eight and nine decidedly transverse, and this coupled with the peculiar modifications of the male anterior femora, (of which no mention is made in the description of *fallaciosum*) and the much smaller size, all seem to indicate that *tropicum* is another species.

Decarthron gracilicorne sp. nov.
(Plate XII, Fig. 15).

♂. Elongate-oval; rufo-testaceous throughout; subimpunctate, shining; pubescence rather short, fine, recumbent.

Head from epistomal margin longer than broad, across eyes equal in width to prothorax; surface very slightly convex along median line, flattened between antennal tubercles; on either side a deep fovea on interocular line; post-antennal sulci deep; antennæ very long and slender, the entire tenth and half of ninth segments passing base of elytra; second segment cylindrical, slightly longer than broad, three to six longer than broad, subequal in length and breadth, three very slightly obconic, seven narrowed at base, of same width as preceding, eight to ten enlarged to form an indistinct club, eight and nine both somewhat narrower at base, ninth very large, ten very elongate-oval, obliquely pointed at apex, as long as the two preceding together.

Prothorax very slightly tranverse, broadest just in front of middle; disk convex, with a small but distinct basal fovea; impunctate, shining.

Elytra transverse, one-sixth broader than long; disk very convex, indistinctly punctulate; sutural striæ deep and entire, discal deep, slightly convergent, not quite reaching middle.

Abdomen shorter than elytra, sides of first segment convergent; carinæ at base occupying almost one-half of the entire segmental width, and reaching middle; second and third dorsal segments with a dense tuft of hair on the posterior margins; undersurface flattened, with a strong carina at the base of the abdomen.

Metasternum broadly concave.

Legs of usual length; anterior tibiæ with a large spatulate spur; middle femora stouter than the others; posterior tibiæ quite strongly arcuate distally.

Length 1 ⅜ mm., breadth ⅝ mm.

♀. Similar to the male, except that the anterior tibiæ lack the spatulate spur and the dorsal abdominal segments lack the tufts of hair; antennal segments four to six slightly shorter, eight subtransverse, nine slightly shorter.

Holotype: ♂, December 19, 1926, at light, Vera Cruz, Ver., Mexico; (Cornell U., Type No. 818.1). Allotopotype: ♀, same data; (Cornell U., Type No. 818.2). Paratypes: 18 ♂♂, 39 ♀♀, same data; (collections of U. S. N. M., Cornell U., A. Dampf, and author).

This very distinct species related to *longicorne* Raffr., characterized particularly by its long and slender antennæ, differs from *longicorne* not only by the presence of tufts of hair, but by the longer discal stria, and the subquadrate seventh antennal segment.

Buris gen. nov. (Tychini).

Genotype *Buris brunneus* sp. nov.

Body euplectiform. Head transverse, with two small foveæ; depressed between antennal tubercles; front modified in male; antennæ widely separated at base, short and thick, segments eight to ten modified

in male; palpi rather long and slender; first segment small, second enlarged apically, third subtriangular, slightly produced internally, fourth as long as the two preceding together, very slender, fusiform, acute at tip, with a strong terminal appendage.

Prothorax very transverse, strongly narrowed at base; no longitudinal sulcus, but a transverse basal one, connecting two very small lateral foveæ. Elytra without trace of basal foveæ; sutural stria fine, but distinct, discal entirely wanting; subhumeral fovea and carina present.

Abdomen without margin except at base of first segment; segments subequal; first ventral long not at all hidden by coxæ; seven ventral segments in male, the last being longitudinally divided.

Legs moderate in length; posterior coxæ widely separated; anterior femora and posterior tibiæ modified in male.

Buris brunneus sp. nov.

(Plate XII, Figs. 21, 22).

♂. Form elongate, euplectiform; testaceous; subimpunctate, shining; pubescence pale, very short, fine, and recumbent, except on sides of prothorax where it is long.

Head transverse, narrowed anteriorly, width including eyes just slightly less than that of prothorax; eyes small, not very prominent; vertex and occiput convex; two very small foveæ just behind the middle line of the eyes, these connected by a more or less evanescent curved sulcus which is lost in a general frontal impression extending between the antennal tubercles; from the convex frontal margin to near the convex vertex, the surface is raised into a rather sharp longitudinal carina, more prominent anteriorly; surface impunctate, shining; antennal tubercles slightly prominent; antennæ short and stout; first and second segments large, subcylindrical, three slightly transverse, four and five more transverse, subequal in length, five a little broader, six and seven very transverse, acute internally, oblique at apex with a thin narrow lamina on inner apical edge, nine more transverse, narrowed internally to a slender, slightly clavate process, tenth irregular, narrowed at base, broadly produced in apical two-thirds, eleven squarely truncate at base, sides near base subparallel, then rapidly narrowed.

Prothorax one-third broader than long, very much narrowed at base; a very small fovea on either side very close to margin, these foveæ connected by a well-defined arcuate sulcus; surface impunctate, strongly shining; lateral margins with a fringe of long hairs.

Elytra one-fourth broader than prothorax, subquadrate; humeral callus rounded, prominent; base without traces of foveæ; sutural striæ fine, entire, no discal striæ; subhumeral fovea distinct and gives rise to a well-marked carina running to apex; surface rather densely, but finely punctulate; pubescence fine and recumbent.

Abdomen longer than elytra, rather slender, evenly tapering to apex; dorsal segments subequal in length; ventral segments flattened along median line; first ventral very long, along median line slightly longer than the following, two to four equal in length, five at middle

much shorter, deeply and broadly emarginate, sixth contained within this emargination, seven smaller, longitudinally divided.

Metasternum large, very slightly concave.

Legs moderate in length; middle coxæ narrowly separated, posterior coxæ widely separated, the distance equal to that of the space between the middle and posterior coxæ; anterior femora swollen, on the antero-ventral surface broadly and deeply concave, making a large fovea which covers a large part of the surface of the femora; middle femora swollen, not as large as the anterior; posterior femora gradually clavate, still more slender; anterior tibiæ slightly arcuate, thickened in distal half, middle tibiæ arcuate, posterior tibiæ strongly arcuate in distal half, with a very small but acute tooth at the beginning of the arcuation.

Length 1 ⅞ mm., breadth ⅜ mm.

♀. Differs from the male described above as follows: head with the same depression, but lacking any trace of the longitudinal carina; antennæ with segments eight and nine simply lenticular, ten almost regularly transverse and squarely truncate at base; prothoracic fringe of hair much finer, shorter and much less conspicuous; ventral segments evenly convex, no seventh segment; metasternum flattened, not concave; femora all slender; anterior tibiæ scarcely evidently arcuate, posterior tibiæ arcuate and slightly swollen in distal half, without tooth.

Holotype: ♂, November 1926, Vera Cruz, Ver., Mexico, in rotten trunk of coco palm; (Cornell U., Type No. 825). Allotopotype: ♀, same data; (author's collection). Paratypes: 6 ♂ ♂, same data; (collections of U. S. N. M., and author).

This genus offers a perplexing combination of characters and does not appear to be closely related to any other described genus. It appears to be more closely related to *Dalmophysis*, than to any other genus, in the vicinity of which it should be placed, but of course is not closely related because of the divided last abdominal segment of the male. It differs moreover from this genus in many particulars of sculpture, modifications of male antennæ etc. The structure of the antennæ in *Buris* is unique and remarkable, but it cannot be made out with the antenna in situ as the segments are so closely appressed that their form is hidden. The above description was written from an antenna mounted in balsam.

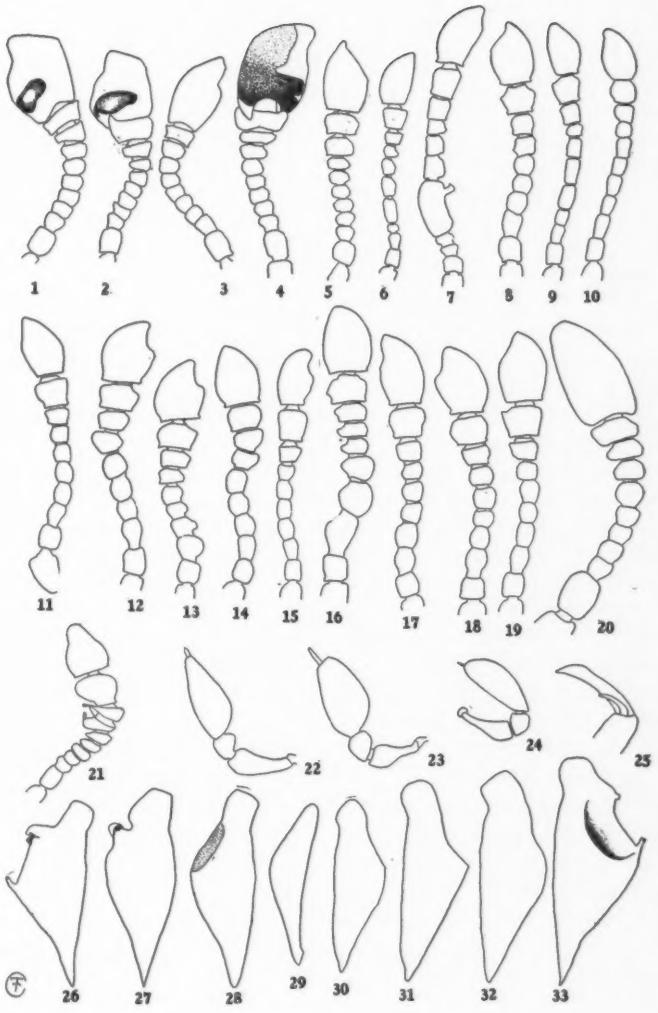
Hamotus (Hamotoides) **tritomus** Reitt.

A single specimen presumably a female was collected under bark of a fallen tree, October 10, 1925, at Las Bocas, where the Rio Hondo is formed, British Honduras. This species has been recorded from Guatemala, Mexico, Nicaragua, Panama, and Colombia.

EXPLANATION OF PLATE XII.

(Figures not drawn to same scale).

Fig. 1. Scalenarthrus ventricosus sp. nov. Antenna. ♂.
Fig. 2. Scalenarthrus globosus sp. nov. Antenna. ♂.
Fig. 3. Scalenarthrus concavus sp. nov. Antenna. ♂.
Fig. 4. Scalenarthrus inflatus sp. nov. Antenna. ♂.
Fig. 5. Eurhexius macrodactylus sp. nov. Antenna.
Fig. 6. Reichenbachia guatemalensis sp. nov. Antenna. ♂.
Fig. 7. Reichenbachia carinifer sp. nov. Antenna. ♂.
Fig. 8. Drasinus hirsutus sp. nov. Antenna. ♂.
Fig. 9. Reichenbachia latipes sp. nov. Antenna. ♂.
Fig. 10. Reichenbachia bifoveata sp. nov. Antenna. ♂.
Fig. 11. Decarthron fractifrons sp. nov. Antenna. ♂.
Fig. 12. Decarthron squamosum sp. nov. Antenna. ♂.
Fig. 13. Decarthron rugulosum sp. nov. Antenna. ♂.
Fig. 14. Decarthron quadrifoveatum sp. nov. Antenna. ♂.
Fig. 15. Decarthron gracilicorne sp. nov. Antenna. ♂.
Fig. 16. Decarthron punctatum sp. nov. Antenna. ♂.
Fig. 17. Decarthron complicatum sp. nov. Antenna. ♂.
Fig. 18. Decarthron denticulatum sp. nov. Antenna. ♂.
Fig. 19. Decarthron tropicum sp. nov. Antenna. ♂.
Fig. 20. Allobrox dampfi sp. nov. Antenna. ♂.
Fig. 21. Buris brunneus sp. nov. Antenna. ♂.
Fig. 22. Buris brunneus sp. nov. Maxillary palpus. ♂.
Fig. 23. Allobrox dampfi sp. nov. Maxillary palpus. ♂.
Fig. 24. Drasinus hirsutus sp. nov. Maxillary palpus. ♂.
Fig. 25. Eurhexius macrodactylus sp. nov. Tarsal claws.
Fig. 26. Decarthron denticulatum sp. nov. Middle femur. ♂.
Fig. 27. Decarthron squamosum sp. nov. Middle femur. ♂.
Fig. 28. Decarthron tropicum sp. nov. Anterior femur. ♂.
Fig. 29. Reichenbachia latipes sp. nov. Tibia. ♂.
Fig. 30. Decarthron denticulatum sp. nov. Middle femur. ♀.
Fig. 31. Decarthron quadrifoveatum sp. nov. Anterior femur. ♂.
Fig. 32. Decarthron tropicum sp. nov. Middle femur. ♂.
Fig. 33. Decarthron quadrifoveatum sp. nov. Middle femur. ♂.



Frank C. Fletcher

NOTES ON THE INJURY TO PLANT CELLS BY CHINCH BUG FEEDING.*

REGINALD H. PAINTER,
Kansas State Agricultural College.

Recent work at the Kansas Agricultural Experiment Station shows that certain varieties of sorghums are far more easily injured by chinch bugs than others. Under moderate infestation last year, the milos, for instance, showed more than 60 per cent injury, while Kansas Orange sorgo and certain Kafirs showed little injury and made nearly complete recovery (2). Varieties of corn such as those studied by Flint (4) showed similar but much less striking differences. If the factor, or factors, that give rise to these differences are to be found, it appears that they should be looked for first at the point of injury. In other words, a study should be made of the injury to individual cells and tissues.

Relatively little information is found in the literature concerning this phase of the biology of the chinch bug, although other Hemiptera, especially aphids, have been studied in this country and Europe by Wells (12), Horsfall (7), Davidson (3), and K. M. Smith (11) in particular. In 1926, Smith gave the results of studies on the method of feeding in several of the families of Hemiptera, but the Lygaeidæ were not among those investigated. Those studied showed considerable variation in the plant tissue sought by the stylets and in the method of reaching the objective.

This paper is intended to deal chiefly with the method of puncture by the chinch bug, the plant cells affected, the objective of the stylets, the injury done to the cells, and the source of the chinch bug's food supply. The feeding habits on different varieties of food plants will be taken up only briefly at this time, but the feeding habits for all instars of the nymph will be compared with those of the adult.

---

*Contribution No. 367, Department of Entomology. This paper embodies some of the results obtained in the prosecution of Purnell, project No. 164, of the Agricultural Experiment Station, Departments of Agronomy and Entomology cooperating.†

†The author is indebted to Mr. S. Fred Prince, the Station Biological Artist, for drawings which were made with the aid of Camera Lucida.

TECHNIQUE AND METHODS.

Smaller nymphs were fixed with their stylets in the plant tissue by means of hot Carnoy's fluid. This worked well occasionally for larger nymphs and adults, but for the most part these latter were fixed to the leaf by dropping melted paraffin on them while they were feeding. This prevented the withdrawing of the stylets until the piece of leaf or sheath could be cut off and the two dropped into hot Carnoy solution after the posterior third of the bug's abdomen had been cut off to insure thorough fixation. The paraffin was removed by subsequent technique. The material was embedded by means of chloroform as a dealcoholizing agent. The method, although taking longer than the usual one, gave excellent results even when the insects were not opened. Sections were cut ten and fifteen micra thick, stained with iron haemotoxylin by the long method and counter-stained with Biebrech's Scarlet. Other methods used are referred to in the text. Champion White Pearl corn and Kansas Orange sorgo were used as representing the more resistant varieties, and "Golden" (g)* corn and Dwarf Yellow milo as representing the more susceptible varieties. Those plants in which the insects were fixed with their stylets fixed in situ had been protected from insect injury, except for thirty minutes or an hour preceding fixation. Other specimens were taken of these and other varieties of cereals on which chinch bugs had been feeding for an unknown length of time under field conditions.

MOUTHPARTS† AND METHOD OF SUCTION.

The mouthparts of the chinch bugs are similar to those which have been figured and described for other Hemiptera. The stylets, which represent the paired mandibles and maxillæ, lie at rest in a groove in the labium. The mandibular stylets are barbed at the distal end, while the maxillary stylets come to a sharp point. The latter, however, when pressed close together as they are in the groove and in the plant tissue, form two canals on their inner facies. The dorsal or suction canal

*A chlorotic mutant for which the gene is located in the second chromosome.

†A recent paper by R. E. Snodgrass (Proc. Ent. Soc. Wash., 29: 1–16) published since this paper left the author's hands, gives a different and probably more correct interpretation and nomenclature for the parts of the Hemipteran head than the current terminology used here.

connects with the pharyngeal pump and carries the food from the plant to the insect; the ventral, or ejection canal, is a continuation of the efferent salivary duct and is a means of carrying the secretions into the plant tissue from the salivary pump. The mechanism for puncturing the plant tissue has been studied by various authors, notably Davidson (3), Grove (6) and Awati (1), and the method is well summarized by Imms (8; p. 332). So far as known, the mode of action in the chinch bug does not differ materially from that described there. The labium shortens by bending ventrally between the first and second joints, allowing the stylets to protrude into the plant tissue.

The morphology of the alimentary canal had been studied and figured by Glasgow (5; Pl. 3, Fig. 7), but the structure of the salivary glands and their connection with the salivary pump have never been described.

THE STYLETS AND STYLET SHEATH IN PLANT TISSUE.

Though the chinch bug has been a severe pest since the beginning of American Agriculture, no one has investigated the exact manner of doing the injury nor the tissues attacked. During the progress of this investigation, the course of the stylets of several dozen insects through the plant cells have been studied. In addition, a number of studies have been made on the tracks these stylets make and leave after they are withdrawn. In all the members of the Hemiptera that have been studied, the path of the stylets through the plant tissue is more or less marked by deposits which form a sheath about them and which have a very definite staining reaction. This stylet sheath or stylet track when made by aphids has been found to consist of callose, calcium pectate, and tannins. The chemical character of the sheath made by the chinch bug has not been thoroughly investigated as yet, but preliminary studies indicate that it is similar to those made by other groups.

So far as the staining reaction is concerned, the stylet sheath is composed of two layers, an inner, or primary, and an outer, or secondary (Figs. 1 and 3). The inner forms a fairly smooth and uniform unbroken coat about the stylets and stains a deep black with Heidenhain's iron haemotoxylin. Occasionally it shows slight annulation and is thickest in the region

of the phloem. The outer coat varies greatly in thickness, both with the different insects or stylet tracks and in the cells of any one section. It is especially thickened and warty in other places. It stains brown or yellowish with iron haemotoxylin and Biebrich Scarlet. The two layers may be easily differentiated in cross and longitudinal section. About the stylets, where they enter the epidermis, is found a hollow cone-shaped mass of the stylet sheath material which consists of both layers (Fig. 4). The hole in the center does not seem to fill up in the stylet tracks examined, but remains open to the inner tissues. To this may be due the presence of a sticky exudation often found on the stems of heavily infested plants. This may result in a lessening of the root pressure in conducting tissue and in the retarding of movement of liquids in the phloem and xylem.

Three possible means exist by which the cell walls may be punctured by the stylets; by direct pressure, by sawing and twisting action of the barbed mandibles, by solution, or by a combination of two or more methods. According to Smith (11), for example, the first predominates among the Miridæ and the last among the Aphididæ, though in all cases a combination of methods seems to occur. A hole formed by the first two means would necessarily be jagged, by the last smoothly round. In most cases it is extremely difficult to determine the character of the puncture from prepared slides, due to the presence of the deeply staining stylet sheath and the thinness of most of the cell walls. However, in two slides made during this study, the character of the puncture is evident. One, the puncture in the leaf of Dwarf Yellow milo, shows a smooth, round hole where the stylets went through the epidermis (Fig. 1). The other shows where the stylets of an insect of unknown age had passed through some five or six cells of the lignified sclerenchyma on the way to a vascular bundle in a leaf of Golden Beauty corn. Here again the passage is a smooth, round hole through the heavy cell walls. In both cases, it seems that solutions played a large part in the formation of the opening. It must be pointed out, however, that cellulose—or lignin—dissolving enzymes have not been found to be produced by Arthropods, although they are produced by other animals and by bacteria and fungi (13). Diastase is the only enzyme which has been isolated thus far from the salivary secretions of any of the Hemiptera. A sawing action is evident in Figures 3 and 6.

The objective of the stylets seems always to be the phloem tissue of the vascular bundle, although they do not reach there in all the punctures examined; but those that do usually throw out branches to all the cells and tubes of that conducting tissue (Fig. 5). The method of reaching the objective appears to be largely trial and error, the stylets passing intracellularly throughout. Long major branches extend in many directions, but end unbranched in single cells unless they reach the phloem. Considering their greater number, the smaller bundles unprotected by sclerenchyma are not attacked any more often than the larger bundles, but where the latter are attacked, the stylets usually go slanting into the bundle from the side (Fig. 2), thus missing the lignified sclerenchyma cells that lie between the bundle and two epidermi. That this method of reaching the phloem is not necessary is shown by one preparation of Golden Beauty corn in which the stylets had passed through the thickest part of the sclerenchyma and of slides of a few other varieties in which several lignified cells are pierced. Of those punctures or branches that do not reach the phloem, some wander aimlessly through among mesophyl cells, others end in the xylem (Fig. 5), while a few reach the epidermis on the opposite side of the leaf or leaf sheath. In the case of one branch to one of the mesophyl cells, the cellulose wall was greatly bent into a pocket, but not pierced by the stylets, which were then withdrawn and sent in another direction. In another preparation, an adult bug had fed in one bundle and when killed had started feeding in another one without entirely withdrawing the stylets. The tubes of the phloem tissue in the first bundle were entirely stopped by plugs of sheath material. The latter condition is frequently found in the stylet tracts where insects had been allowed to feed uninterrupted, (Fig. 5). The branches to the xylem may be an extra source of water for these insects, especially through a very dry period. Only a few of the branches that reach the opposite side of the leaf actually pierce the outer epidermis; most of them end in the epidermal cells. In those cases where parts of the stylet sheath appear through the outer wall of these cells, it is evident that only the very tips of the stylets have pierced the outer covering. In only one case had the stylets passed through one leaf sheath and entered that below. Hence, in smaller plants, the chinch bugs rarely feed on the stem as has been often stated in the literature, but rather

on the leaf sheath, as they cannot reach the short internodes, except through these sheaths. Very often, in the larger plants, the insects show a decided preference for feeding on the inside of one sheath, or the outside of the next, rather than on the stem proper.

CELLS AFFECTED AND INJURY.

The following cells and tissue have been found punctured by the stylets: epidermis, mesophyl phloem, companion cells of the phloem, protoxylem, bundle parenchyma, xylem, and the lignified bundle sclerenchyma. Occasionally cells pierced by the stylets show some of the contents removed, plasmolysis, or a clumping of the cytoplasm near the stylet sheath. On the whole, however, there is surprisingly little injury to the cells compared with that found in some Miridæ; for instance, where twenty or thirty cells may be found injured, this latter resulting in a "shot hole" appearance of the younger tissue injured. The actual damage done to the plants consists largely of the removal of the synergic food-bearing solutions which flow to the roots by way of the phloem; the stopping up of the sieve tubes, and perhaps also the removal of water from the xylem, together with the stoppage of the tracheids, (Fig. 5). These observations agree well with those for plants on which definitely known numbers of chinch bugs have been caged under controlled conditions. Under a heavy infestation, the leaves wither while still green, showing a lack of water either from stoppage of the xylem or removal of the liquids from the phloem more quickly than the roots can supply it. This withering usually takes place at a considerable distance from the point of feeding of the bugs, always starting at the tip of the leaf. A rain will quickly revive a plant in this condition. Under a lighter infestation, the leaves become yellow, the root system becomes weakened, both due to the removal of food from the phloem tubes and their stoppage with a plug formed of the stylet sheaths. This material may be permeable, but diffusion through it is certainly at a slower rate than through the unimpeded ducts. Furthermore, the gregarious habit of the chinch bugs in their feeding, whether due to instinct or to a change in the plant tissue favorable to them, results in more damage to the plants, especially in regard to the plugging of the vessel.

THE FOOD SUPPLY OF THE CHINCH BUGS.

The food of the chinch bugs then is derived largely from the phloem tube. This system for conduction and storage is especially rich in proteins and carbohydrates which the chinch bug can make use of readily. The nature of the liquid has been shown to vary, not only in different species of plants, but also with differences in maturity. It may also very possibly be of importance in the problem concerning the susceptibility of varieties to chinch bug attack.

FEEDING OF NYMPHS AND ADULTS.

In most of the preparations, the instar of the nymph is known. So far, no one has attempted to find out whether there are any changes in the feeding habits correlated with the age of the individual Hemipteran—factors which may be of considerable importance in a problem of this kind. However, the chinch bug shows very little variation in this regard. In the thinner parts of the leaf, the older nymphs and adults send in their stylets quite straight, while the piercing organs of the younger nymphs follow a more or less crooked route. Near the midribs and other thick parts, the tracks of the nymphs and adults are never straight. Indeed, one of the most tortuous of the entire study was that of an adult previously mentioned which was feeding on Dwarf Yellow milo. Two bundles had been tapped and the stylet track extended over an area 150 by 430 micra. The stylet tracts themselves, like the stylets, are about twice as wide when made by adults as when made by the first instar nymphs. The former is usually about 3–2500 mm. in width, the latter about 15–25000 mm.

FEEDING HABITS ON DIFFERENT HOST PLANTS.

The study of the difference in feeding habits on the varieties of sorghums and other cereals is not yet completed, but there seems to be at least one notable difference in the reaction of the plants. It has already been pointed out that the sheath is composed of two distinct layers. Petri (10), in his researches on the feeding habits of *Phylloxera* and other insects, has given evidence that the outer sheath is composed of tannins, while the inner is of calcium pectate and callose. In Dwarf Yellow milo which is very susceptible to chinch bug attack (2)

the outer stylet sheath is quite thin compared with the inner (Fig. 1). In Kansas Orange sorgo, the reverse is true (Fig. 2). The inner sheath is frequently almost lacking, while the outer is thick with many enlargements. If, as seems probable, this outer sheath is of tannin, this reaction may be significant in explaining the resistance of certain varieties, as tannins have been reported as being an important factor in protecting plants against the attacks of parasitic fungi. Further evidence is given by the fact that in the single case studied, a resistant hybrid between Dwarf Yellow milo and Kansas Orange sorgo has a sheath similar to the resistant parent. The two corn varieties studied show somewhat similar and parallel kinds of sheaths, but the contrast is less striking than among the sorghums. This agrees with field observations where the contrast between susceptible and resistant varieties of corn is not as great as between the varieties of sorghums. Sufficient studies have not been made to warrant a definite statement concerning the effect of this outer sheath, but the difference found encourages further work along this line. From the structural standpoint, the presence of numerous small cross veins or more complete anastomosis would be of advantage to a plant in overcoming the obstacles presented by the plugging of the conducting tissues.

SUMMARY.

1. Evidence is given that the dissolving action probably of the salivary fluid plays an important part in enabling the chinch bug to puncture the plant cells. It is aided by pressure on the stylets.

2. The sheath formed about the stylets consists of two layers of separate staining reactions. The inner is stained black with iron haemotoxylin, the outer brown or yellow and is especially prominent in the epidermal cells and the xylem.

3. The objective of the stylets is usually the phloem tissue of the vascular bundles where a number of branches are sent to the various tubes.

4. Besides the phloem, the xylem, epidermis, mesophyl, sclerenchyma, protoxylem, and bundle parenchyma tissues are pierced.

5. The stylets enter the vascular bundles between the two masses of lignified tissue usually found between the epidermis

and the bundle, but sometimes they go through the heaviest part of the sclerenchyma, always passing intracellularly. More than one bundle may be tapped without withdrawing the stylets. The smaller vascular bundles, unprotected by the lignified tissue are, considering their greater number, no more often attacked than the larger bundles.

6. There is relatively very little injury to the cells pierced by the stylets. The injury to the plants comes mainly from the withdrawal of the fluid from the phloem and xylem tubes and the stoppage of these conducting tissues by sheath material resulting in the starvation of the roots for synergic foods and the leaves for moisture.

7. The source of the food supply of the chinch bug is almost entirely the phloem tissue.

8. The feeding punctures of the nymphs and adults show only small differences correlated with the doubling of the size of the stylets during growth.

9. Preliminary evidence is given that the presence of tannis may be of importance in the problem of resistant and susceptible varieties.

BIBLIOGRAPHY.

1. **Awati, R. P.** 1914. The Mechanism of Suction in the Potato Capsid Bug. Proc. Zool. Soc. Lond. 1914, 685-733.
2. **Call, L. E.** 1926. Kansas Sta. Bien. Rept. 1925–1926, p. 76-78.
3. **Davidson, J.** 1923. Biological Studies of Aphis rumicis Linn. Ann. App. Biol., 10: 35-54; 1 pl.
4. **Flint, W. P.** 1921. Chinch Bug Resistance of Certain Varieties of Corn. Jour. Econ. Ent. 14: 83-85.
5. **Glasgrow, H.** 1914. The Gastric Caeca and the Caecal Bacteria of Heteroptera. Biol. Bull. 26: 101-156; 4 pl.
6. **Grove, A. J.** 1919. The Anatomy of the Head and Mouthparts of Psylla Mali, the Apple Sucker, with Some Remarks on the Function of the Labium. Parasitology, 11: 456-488.
7. **Horsfall, J. L.** 1923. The Effects of Feeding Punctures of Aphids on Certain Plant Tissues. Penn. Agri. Coll. Exp. Sta. Bull. 182; 22 pp.
8. **Imms, A. D.** 1924. A General Text Book of Entomology. New York. E. P. Dutton & Co.
9. **McColloch, J. W.** 1924. The Resistance of Plants to Insect Injury. Kans. State Hort. Soc. Bien. Rept. 37: 196-208.
10. **Petri, L.** 1909. Uber die Wurzelfaule Phylloxierter Weinstocki. Leitsch. Pflanzenkr. 19: 18-48.
11. **Smith, K. M.** 1926. A Comparative Study of the Feeding Methods of Certain Hemiptera. Ann. App. Biol. 13: 109-137.
12. **Wells, B. W.** 1920. Early Stages in the Development of Certain Pachysylla Galls on Celtis. Amer. Jour. Botany. 7: 277-285.
13. **Yonge.** 1925. The Digestion of Cellulose by Invertebrates. Science Progress. Vol. 20, No. 78.
14. **Yuasa, Hachiro.** 1918. An Extra Molt in the Nymphal Stages of the Chinch Bug. Ent. News. 29: 233-234.

EXPLANATION OF PLATE XIII.

Fig. 1. Hole made through epidermal cell of Dwarf Yellow milo by stylets of adult chinch bugs, showing comparative thickness of the two sheaths.

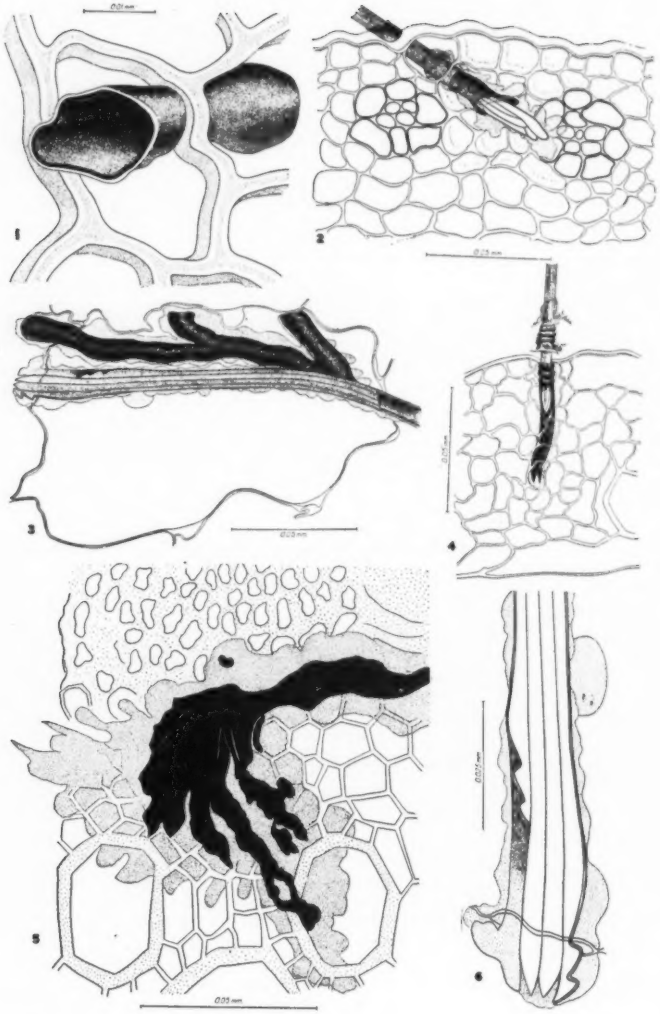
Fig. 2. Stylets of fourth instar nymph in place in cells of Kansas Orange sorgo, showing comparative thickness of sheaths.

Fig. 3. Stylets of third instar nymph in mesophyl cell of Golden Beauty corn, showing beginning of branches of previous attempts to reach phloem marked by sheaths remaining after stylets have been withdrawn.

Fig. 4. Stylets of first instar nymph in leaf of Champion White Pearl. Two cones of sheath material outside the epidermis have been formed about the stylets by the plant following two attempts to reach the phloem. The next section on the slide proves that the second attempt was successful.

Fig. 5. Stylet tract of chinch bug in vascular bundle of Golden Beauty corn. Many branches run to different tracheids and to the xylem, almost entirely plugging the phloem with sheath material.

Fig. 6. An enlargement of the stylets from Figure 3 to show the character of their tips and the independent sawing action apparently used in piercing cell walls.



Reginald H. Painter

THE PERIODIC VIBRATORY MOVEMENTS OF THE LARVA OF NYMPHULA MACULALIS CLEMENS (LEPIDOPTERA) AND THEIR RESPIRATORY SIGNIFICANCE.*

PAUL S. WELCH AND GEORGE LOUISE SEHON.

INTRODUCTION.

That certain aquatic caterpillars regularly exhibit periodic vibratory movements of the anterior portion of the body was long ago recorded by Buckler (1875, p. 161), Miall (1895, p. 232) and others and, by inference, a respiratory function was assigned to them. The senior author (Welch, 1916, pp. 170-173; 1924, pp. 398-399) has already described, among other things, the case making activities of the larva of *Nymphula maculalis* Clemens and indicated a form of locomotion resulting from somewhat similar movements when the body is partly projected from detached cases. Performance of these movements both by larvæ wholly within cases—a position not related to any form of locomotion—was also observed but not studied until recently. The regular occurrence of large numbers of these larvæ in the region of Douglas Lake, Michigan, provided a generous supply for experimental purposes and during the past summer the writers undertook a study of these characteristic vibrations.

The larvæ of *Nymphula maculalis* are truly aquatic; live wholly submerged in the water; and possess in the last larval instar an equipment of over 400 gills (Welch, 1916, p. 169), the structure of which has already been described (Welch, 1922, pp. 32-37). They are easily maintained alive in the laboratory by simple imitation of the field conditions under which they exist and their various transformations readily followed. Excellent condition of the material kept in the laboratory was thus insured, although stocks fresh from the field were frequently provided.

*Contribution from the University of Michigan Biological Station and from the Zoological Laboratory, University of Michigan.

NATURE OF VIBRATIONS.

Description.—Buckler (1875, pp. 161-162) described certain movements in "Paraponyx stratiotalis" as follows: "Night and day, at intervals varying from one to three minutes apart, the larva, holding to its web by the anal legs, rapidly undulates its body upwards and forewards with considerable vigour and energy, while the three hinder segments appear motionless; this intermittent movement lasts about twenty-one seconds at a time, and is followed by a period of rest—longer, that is for two or three minutes—when the larva is quiet, and shorter when it is feeding, at such times not exceeding one minute. That this energetic undulation is connected with the respiration of the larva is evident from the fact that the branchial filaments are then all in strong action, for, instead of radiating as they do in repose, they become depressed a little, and point forwards in the direction of the head." Similar statements appear elsewhere, in the literature, some of them apparently having been taken from Buckler. With the exception of certain details this description fits fairly closely for similar movements of the larvæ of *N. maculalis*. Buckler's argument for a respiratory function is, of course, very inconclusive.

When the vibrating movements are performed by the larvæ of *N. maculalis* anchorage to the case is secured by the hooklets of the posterior prolegs, often only the terminal pair, but sometimes the last two or three pairs participate. The anterior portion of the body is raised free of the case and is swung rapidly and vigorously in an undulating, horizontal motion. The general effect is that of an energetic lashing of the forebody from side to side. While the usual body position is parallel to the long axis of the case, these movements may be manifested in other positions as well. What appears to be the same form of lashing may be performed either wholly within the case or with the anterior end projected from the case, but as will be shown later the two sets of circumstances are wholly different and independent, and the latter seems to have no relation to respiration.

Methods of Examination.—Although the case is commonly composed of two parts—the upper and the lower halves—it is often possible to observe the larval movements by transmitting light through it, especially in the case made from the thinner

leaves and margins of leaves. However, it was found that observation could be greatly facilitated by cutting one to three tiny windows in the upper half of the case. Such openings did not interfere with the activity of the larvæ.

Frequency of Vibration under ordinary Conditions.—This vibration occurs in periods of continuous almost uniform swinging from side to side separated from one another by intervals of complete cessation. Since as will be shown later the frequency of these vibration periods varies definitely with changes in certain of the environmental factors discussion of this point will be deferred. The number of individual swings composing a vibration period also varies. In a series of counts made on ten larvæ, in lake water, at a temperature of 18.8 degrees C., and including eight successive vibration periods for each, it was found that the range of variation for the total count (all larvæ) was 5-25 swings. In this paper a movement from one side of the main axis to the other is referred to as a *swing*. In the totals of the eight successive vibration periods mentioned above larva No. 5 manifested 65 swings while larva No. 2 showed 136. The average of the 80 counts was 12.7 swings.

The time interval between vibration periods also varied to some extent depending upon external conditions. Reference will be made to this feature in a succeeding paragraph.

FUNCTION OF VIBRATION.

Relation to Feeding Movements.—Any movements related to feeding are independent of the periodic vibrations. Feeding, or exploration preliminary to feeding, almost invariably occur when the anterior part of the body is extended from the case, while the lashing motions under discussion are manifested almost wholly within it.

Relation to Silk Production.—Careful observation showed that the vibrations were not related to silk production and silk attachment activities. Silk is formed and anchored within the case by much slower and less regular movements. Likewise, their direction is much more varied because of the necessities involved in properly relating the silk to the inside of the case. The silk strands are not strung from side to side across the interior of the case; nor do the periodic lashings make contact with the case at the extremes of the swing.

Relation to Excreta.—As pointed out previously (Welch, 1916, p. 174). all excrement is voided outside of the case thus providing for the continued cleanliness of the interior. The larva backs partly out of the case and with the posterior end well protruded forcibly expels the waste into the water. There is no evidence that waste disposal has any relation to the vibratory movements. The latter occur very frequently while excretion is relatively infrequent. Furthermore, the lashing movement of the anterior end was never observed to coincide with waste expulsion.

Relation to Locomotion.—In an earlier paper (Welch, 1916, p. 172) a somewhat similar movement was described which is responsible for a curious form of locomotion. However, it occurs only when the anterior end of the larva is projected well outside the case and, while vigorous side to side motions are executed, the strokes were often stronger on one side than the other. Such activity was infrequent and sporadic compared with the more or less regular occurrence of the vibratory movements within the cases. Available evidence indicates that these are wholly different and independent kinds of activity and that the latter is unrelated to any form of locomotion and results from a different set of influences.

Relation to Temperature.—In order to determine the influence of temperature on the frequency of vibration periods experiments were performed with groups of larvæ in the later instars, those of each set of experiments being of equivalent size. The methods employed were relatively simple. Open glass dishes containing unmodified lake water were sunk for almost their entire depth in larger dishes containing water of the desired temperature, secured by the combined use of ice, well water and heated water. By such arrangement and its proper manipulation it was possible to maintain a desired temperature for the period of the experiment. The following tables contain condensed data secured from these experiments and indicate the general results.

Owing to the fact that the vibration period frequency varies so widely and also that a single vibration period is composed of a variable number of swings, no attempt has been made to give the data formal statistical treatment. However, since the principal trends of the results have been obvious, the totals have seemed to be significant and sufficient for the purpose of this paper.

All numbers in the following tables refer to vibration *periods* only.

TABLE I.

Eight Larvæ; Lake Water; Dissolved Oxygen Content at 20.5° C. = 5.65 c. c. per 1; Interval 30 Minutes.

Temperature (°C.)	7.2	13.3	18.8	23.3	30
Maximum	4	11	23	29	39
Minimum	0	1	3	4	8
Totals	5	38	96	139	142
Average	0.6	4.7	12	17.3	17.7

TABLE II.

Fifteen Larvæ; Lake Water; Dissolved Oxygen Content at 20.5° C. = 5.65 c. c. per 1; Interval, 30 Minutes, except for 31 Degrees, which is only 10 Minutes.

Temperature (°C.)	6	13.3	17.7	20	25	31*
Maximum	3	12	30	30	34	29*
Minimum	0	3	4	2	4	3*
Totals	6	92	238	227	260	256*
Average	0.4	6.1	15.8	15.1	17.3	18.2*

*NOTE.—Interval of 10 minutes only.

TABLE III.

Ten Larvæ; Lake Water; Dissolved Oxygen Content at 20.5° C.= 5.65 c. c. per 1; Interval, 15 Minutes.

Temperature (°C.)	4.4	11.6	16	18.8	24.4	28.9
Maximum	4	11	26	30	40	46
Minimum	0	0	0	1	4	5
Totals	4	26	57	91	131	166
Average	0.4	2.6	5.7	9.1	13.1	16.7

TABLE IV.

Ten Larvæ; Lake Water; Dissolved Oxygen Content at 20.5° C. = 5.65 c. c. per 1; Interval, 10 Minutes, except for 30.4 Degrees, which is 5 Minutes.

Temperature (°C.)	6	12.7	18.3	18.8	24.4	30.4*
Maximum	0	7	10	15	20	12*
Minimum	0	0	0	1	0	0*
Totals	0	21	47	73	99	82*
Average	0	2.1	4.7	7.3	9.9	8.2*

*NOTE.—Interval of five minutes only.

A similar experiment was performed with 20 larvæ, interval of 10 minutes, and with temperatures and dissolved oxygen contents as follows: (1) 8.3 degrees and 5.16 c. c. per 1. 0_2; (2) 12.2 degrees and 5.3 c. c. per 1. 0_2; (3) 18.3 degrees and 5.5 c. c. per 1. 0_2; (4) 23.3 degrees and 5.5 c. c. per 1. 0_2; and (5) 27.2 degrees and 5.0 c. c. per 1. 0_2. The dissolved oxygen was thus controlled within narrow and insignificant limits. The results of this experiment were essentially the same as shown in the four tables given above.

In all of the experiments described above larvæ were returned to normal conditions and given generous recovery time before being retested. Also the tests always progressed in regular sequence towards the minimum or maximum temperature.

These summarized data indicate a very definite increase in the frequency of the vibration period with increase of temperature. Evidently a temperature of 4.4 degrees C. is near the complete inhibition point, although a variation exists as indicated in tables 3 and 4. Also under the highest temperatures inconsistency of results, occasional death of larvæ, and evident fatiguing of larvæ seem to indicate that temperatures of 30 degrees or more are approaching the upper critical point. In tables 2 and 4 it will be noted that the tests for 30.4 and 31 degrees, respectively, were run for smaller periods than those of the experiments to which they belong, since it was evident that the conditions were no longer normal and that in some cases at least the larvæ might not live through a longer exposure.

In table 2 it will be noted that 20 degrees gave a smaller total than did 17.7 degrees, a result which does not conform with the other trials. Scrutiny of the data yields no obvious explanation of this deviation. However, in table 3 the temperature of 16 and 18.8 degrees yielded results consistent with the general findings.

Effect of artificially produced Current through Case.—Early in this work it was observed that the vibration movements tended to produce a current of water through the case. If such a current be produced artificially, what would be the effect on these movements? By means of an elevated reservoir containing lake water it was possible to lead a controlled stream into one end of a larval case by means of a rubber tube which terminated in a short piece of glass tubing so drawn out at the

end as to allow easy insertion into one of the terminal openings of the case. Flow of current was governed by an adjustable cock. Unfortunately it was not feasible to attempt to measure the rate of current within the case, hence the outcome can only be stated in terms of general results. Within the necessary limits, the faster the current thus produced the greater the elimination of the vibratory movements. The slowest current reduced the vibration periods as compared with the controls; a fast current resulted in complete cessation of vibrations during the period of the experiment, namely, 15 minutes; between these extremes intergrading reduction of movements occurred.

Since within limits higher temperatures increase the number of oscillation periods per unit of time an experiment was performed using artificial current through the cases as described above under conditions of higher temperatures to determine whether a gentle current would inhibit the stimulating effect of the increased temperature. The experiment was performed on a set of 18 larvæ in their cases in unmodified lake water at temperatures of 25-26.6 degrees. Two sets of controls were maintained, one at 20 degrees and the other at 26.6-27.2 degrees. The controls performed in the expected way, the one at 20 showing a total of 92 vibration periods in 10 minutes, while the one at 26.6-27.2 degrees yielded a total of 169 for the same period. The experiment, however, gave only 22 vibration periods, 10 of the 18 larvæ exhibiting no lashings at all, and the maximum for those which did being only 5. It thus appears that a gentle current through the case largely overcomes the accelerating effect of the higher temperatures. Experiments also showed that at any of the temperatures under which these larvæ manifest vibration periods in a normal way (about 4.4-26.6 degrees artificially) produced current through the case tended to reduce and even inhibit the oscillations.

Substitution of Glass Tubes for Normal Cases.—After some practice it was found possible to induce a larva to enter, without injury to itself, a piece of glass tubing, the diameter of which closely approximated that of the space within the normal case.

Since it appeared necessary for these larvæ to find holdfast with the posterior prolegs in order to perform the lashing movements, a strip of leaf was introduced into each tube to supply possible attachment. However, this plan was soon

abandoned since it was discovered that the larvæ were able to attach silk to the glass walls and thus apparently provide the necessary anchorage.

Shortly after introduction into glass tubes the larvæ executed the vibratory movements in the normal fashion with the expected intervening intervals. The ends of the tubes were open and the whole submerged in unmodified lake water. Tubes of smaller diameters restricted the freedom of movement and results were more irregular. However, in larger tubes whose diameters exceeded those of the larvæ the frequency of the vibration periods was not significantly different from that in the normal cases.

When the ends of the tubes were closed with a coarse mesh scrim and the whole submerged in lake water in such a way as to avoid inclusion of air films or bubbles, normal activity was somewhat modified, probably due to the fact that the scrim offered some resistance to the production of current through the tube. As a consequence, larvæ which manifested what appeared to be vibratory periods for several hours ultimately (within about 24 hours) showed delaterious effects in the form of an increasing inertness leading to the death of some individuals.

In experiments in which one or both of the ends of the glass tubes were closed with a solid plug thus largely or wholly interfering with current production the larvæ soon exhibited unusual movements, often in the form of a constant turning around, end for end, in the tube. Occasionally a larva soon developed inertness and remained in that condition. Often the vibratory movements appeared at first but were soon succeeded, almost invariably, by the abnormal movements just mentioned. Such experiments seemed to demonstrate the necessity of a current provision of some sort and within a relatively short time.

By the use of these tubes as substitutes for normal cases it was possible to detect the production of a definite current by the lashing motions of the larvæ. Finely divided, insoluble particles of light specific gravity were added to the water and it was not difficult to follow their journey through the glass case. The direction of passage was found to be from the posterior towards the anterior end of the animal. However, the current is normally a very gentle one, not strong enough to move a fine thread which was attached to the end of the case.

By means of floating particles it was also possible to verify the production of this current in the regular leaf cases.

Effect of Partial Case Removal.—Several experiments were performed to determine the result of removing the upper half of the larval case, thus exposing the larva and the whole interior of the lower half of the case to the general conditions of the surrounding water. These tests involved the use of unmodified surface lake water in an open shallow dish, room temperature, and periods of 10 to 20 minutes. Of 30 specimens tested, only one showed any undulatory movement at all. It was noted, however, that if the lower part of the case on which the larva lies be unusually deep and concave, the larva will occasionally show the lashing motions when the top is absent. When a larva, from whose case the top had been removed, succeeded in inverting a new lid over itself it began to exhibit the characteristic vibratory movements immediately even though the lid is not in the correct position and the anterior end alone is covered. Apparently exposure to the open water removes the stimulus for vibratory movements. Also it should be noted here that a larva completely removed from its case and placed in the conditions described above does not exhibit these motions, although random movements of the body may be performed.

Relation to Dissolved Oxygen Content.—If these movements are concerned with respiration it would seem that they might show some relation to variations in the dissolved oxygen content of the water. Therefore, a series of experiments was performed to test this possibility.

The wells at the Biological Station, constructed by driving an iron tube into the sand at some little distance from the lake margin, furnish water which is almost devoid of dissolved oxygen. Ordinary pumping activities adds, by agitation, a small amount of oxygen to the water as it flows from the spout. A piece of rubber tubing placed with one end inside of the pump and resting on top of the plunger acted as a siphon when the pump was in action and thus modified well water was conveyed into the sampling bottles and other receptacles without appreciable addition of oxygen. Since it had already been found that the larvæ of *Nymphula maculalis* will thrive in this well water provided it is well aerated, it was used as the medium in some of the experiments.

Experiment 1.—In well water with very low dissolved oxygen content.

This experiment was of a preliminary nature in order to determine the probable response of the larvæ to low oxygen content. Unmodified well water was introduced into a series of 10 vials, carefully corked so as to exclude air bubbles. These vials were placed into a large jar which was then filled with well water, the top clamped on, and the whole allowed to stand for 6-7 hours in order that the water might assume the temperature of the room—the temperature at which the larvæ were living in the stock aquarium and near which they commonly existed in the field. The jar was then opened, the small bottles withdrawn, and to each was added one larva in a complete leaf case, the latter having had two small observation holes cut in the top half to facilitate the detection of movements. These bottles were then corked again, care being taken to avoid inclusion of air, and the larval reactions observed for a period of 15 minutes. Controls prepared in a similar fashion but with specimens in ordinary lake water containing an ample amount of dissolved oxygen were also under observation. In the experimental bottles the larvæ at once exhibited signs of uneasiness, became agitated, and throughout the period of observation frequently extended themselves partly from the cases. The general reaction was the same in all specimens, namely, vibration periods separated by quiescent intervals occurred at first but soon gave place to a continuous vibration which continued until the end of the experiment, interrupted only by sporadic extensions of the anterior end from the case. In the controls, the specimens exhibited the periodic vibrations in the usual fashion and in the expected frequency for the temperature involved. Apparently, then, the low dissolved oxygen content of the well water called out an unusual amount of body vibration.

This experiment was repeated on two other groups of 10 larvæ each with closely similar results. All of the specimens soon performed the continuous lashing movements.

Experiment 2.

Ten specimens were tested in well water in the same fashion as indicated in experiment 1 except that one-half of each case had been removed, thus exposing the larva to the surrounding water more completely. Controls in aerated well water were provided, and showed no vibration movements during the 15 minute experiment interval. On the other hand, the experimental larvæ all showed several lashing periods and three soon developed the continuously lashing condition. Evidently, the low oxygen content is the stimulus which produces the active movement.

Experiment 3.

Experiments were then performed to determine the relation of these movements to known amounts of dissolved oxygen, varying from the ordinary ample quantities present in lake water to greatly reduced ones. To secure water with different low oxygen contents three procedures were used: (a) carefully collected well water which was pro-

gressively aerated, as desired, by mechanical stirring with surface exposed to the air; (b) boiled, filtered lake water, cooled to desired temperature in carefully sealed receptacles and later either aerated progressively by mechanical stirring or by the addition of ordinary filtered lake water until the desired dissolved oxygen content was secured; and (c) the addition of filtered lake water to well water in such quantities as to yield media of different oxygen content. For purposes of these general experiments, media prepared in any one of these three ways appeared to be about equally satisfactory. Dissolved oxygen content was determined by use of the modified Winkler method as described in the Standard Methods of Water Analysis, sixth edition, 1925. The procedures and necessary precautions involved in such analyses are too well known to justify description here.

As in the temperature experiments, it was found that in spite of the fact that the specimens used were all of the same instar, there was a wide variation, statistically, in the frequency of the vibration manifested by different specimens. Some individuals showed low frequency in their reaction under the various experimental conditions, while others were of the opposite reaction, with various intergrades between the two extremes. Nevertheless, in spite of the individual differences, the general tendency of the results was the same. In the presence of such variation it seemed best, for the purposes of this paper, to use the total vibration periods or the arithmetical average for all of the experimental larvæ over the time of the experiment when comparing results.

The results of the following experiment are typical. Twenty larvae were used and the tests extended over a period of 15 minutes.

TABLE V.

Oxygen, c. c. per l.	Temperature (°C.)	Total Vibration Periods	Average
0.17	17	8 constant vibration; 11 periodic but rapid; 1 none	
0.59	18.3	233	11.6
1.11	18.5	164	8.2
1.67	19.4	162	8.1
2.33	19.4	136	6.8
4.15	19.4	128	6.4
5.5	15.6	119	5.9

Doubtless the totals mentioned above were affected to a slight extent by the inability to keep the temperature at exactly the same level, but the temperature differences are so small that the results are, for general purposes, comparable. Two other experiments of the same nature were performed, differing only in the temperature at which the test was made and in the amounts of dissolved oxygen in the various media, one varying from 0.14 to 5.65 c. c. per 1. and the other from 0.97 to 5.51 c. c. per 1. In one the temperature was controlled at 23.3-23.9 degrees, in the other at 18.3-20 degrees.

All of the experiments gave similar general results. Reduction of dissolved oxygen led to an increase in the number of vibration periods, the low quantities causing a tendency to vibrate constantly. Uninterrupted lashing doubtless indicates an extreme at which the effect becomes pathological and the larva would probably live but a short time in such water. It was noticed that after a time the lashing begins to run down, possibly due the combined effect of the very low oxygen content and increasing exhaustion. The experiment conducted at 23.3-23.9 degrees C. indicated that a higher temperature produces a larger total for any of the various oxygen contents and the onset of constant vibration appears at a distinctly greater oxygen quantity. In all of the totals the decrease in vibration periods was relatively small until the oxygen content fell to roughly about 1.0 c. c. per liter, below which its decrease was marked. While seemingly sensitive to oxygen reduction in the higher quantities, conspicuous sensitiveness occurs on extreme reduction.

Immobilization Experiments.—In order to determine how vital these movements are to the well-being of these insects larvæ were immobilized by introducing them into elongate cylinders made of coarse-mesh silk bolting cloth which invested the body closely without exerting pressure. These cylinders possessed sufficient rigidity to prevent the lashing movements. Since the larvæ would invariably attempt to move lengthwise when lateral motion was impossible, it was necessary to tie off the cylinder close to the anterior and posterior ends. Each larva so prepared was suspended horizontally in ordinary unmodified lake water at room temperature. By the use of the coarse-mesh bolting cloth only a minimum of the surface

of the animal was covered and water had free access to practically the whole of the body. Also such an investment permitted the gill filaments to project freely through the meshes into the surrounding water. Thus the normal relations were preserved as nearly as possible, save that the periodic lashing was prevented.

Since it was not possible to judge the well-being of a larva so immobilized at any particular time without removing the investing cylinder and thus interrupting the experiment, the difficulty was solved by preparing a considerable number of larvæ simultaneously, starting all of them at the same moment and under the same conditions, and then examining one at a time at selected intervals until the whole group was used up. Results had to be judged from (1) the amount of activity manifested voluntarily, and from (2) the response to various artificial stimuli, when the larvæ were removed from the gauze cylinders and placed in lake water after the selected immobilization period.

Sixteen larvæ were tested, released, and examined at intervals of from 2½ to 90 hours. After about 8 hours, experimental larvæ were found to be inactive when released, although they soon resumed activity when restored to normal conditions. Those kept immobilized for more protracted periods (45 up to 90 hours) invariably became inactive, apparently after about 8 hours, and continued so until released, after which they ultimately recovered, although those submitted to the longer periods required some 3 to 5 hours for this recovery. When first released and for some time thereafter they were to all appearances dead and gave no response to contact stimuli.

That recovery followed release after 90 hours of continuous immobility seems to indicate that while the vibratory movements are necessary for normal body activity of the usual sort, the larvæ can survive for protracted periods in a state of what seems to be complete inertness. Possibly enough oyxgen could be secured from the motionless water to maintain life in a state of reduced activity.

DISCUSSION.

The results described in the fore-going pages indicate that the periodic, horizontal lashing movements of the larva of

Nymphula maculalis have a respiratory significance, their immediate function apparently being to provide the necessary renewal by circulation of the water which is in immediate contact with the gills and the general body surface. The necessity for such agitation of the water is easily understood because (1) the normal habitat of this larva is in the very quiet water of the lily pad zones; (2) the water within the case is to a large degree pocketed and rendered completely motionless; and (3) the gills have no ability to move independently. Since this larva never provides itself with an investing layer of air from atmospheric sources, as does some of its near relatives, its whole oxygen supply must come from the dissolved oxygen of the surrounding water. Doubtless the water immediately in contact with the body soon develops a reduced oxygen tension and some form of renewal is required. The absence of such movements when the larva is engaged in other forms of bodily activity, as for example, locomotion, feeding, silk production, is understandable since the water renewal is automatically accomplished.

The evidence that these movements are directly related to respiration can be summarized as follows: (1) The periodic nature, consisting of intervals of vibration followed by intervals of complete rest; (2) the rough approximation to regularity in the performance of the lashing intervals; (3) the actual production of current through the case; (4) the independence of these periodic movements of the other forms of normal activity; (5) their complete absence when other body movements are in progress; (6) the invariable performance of these movements in complete cases, either normal or artificial; (7) their almost complete absence when one-half of a normal case is removed or when the larva is completely removed from its case; (8) the increase in frequency up to constant vibration with increasing reduction in the dissolved oxygen content of the water, this being true for the various temperatures used; (9) the conspicuous acceleration of the frequency after the dissolved oxygen content falls to about 1.0 c. c. per liter; and (10) the reduction of general well-being by immobilization in otherwise normal and favorable conditions.

SUMMARY.

1. The larvæ of *Nymphula maculalis* normally and regularly perform periodic, horizontal lashing movements of the anterior region at times when not engaged in other forms of body motions.

2. These vibratory movements are independent of the regular activities of feeding, silk production, deposition of excreta and its disposal, and locomotion.

3. Frequency of the vibration period increases with the rise in temperature within a range of about 4.5 to 30.5 degrees C. Complete inhibition of movement occurs near 4.5 degrees and as the temperature approaches about 30.5 degrees the periodicity tends to give place to constant vibration and pathological conditions.

4. In the normal leaf cases these movements produce a definite current.

5. Artificial current through the normal case produces distinct reduction of the vibration periods and on further increase in rate of current they cease completely.

6. When pieces of glass tubing were substituted for the normal cases, the vibratory movements were performed in much the usual fashion, and the production of water current was demonstrated.

7. Increased exposure of the larva to the surrounding water by the removal of one-half of its normal case, almost invariably eliminated the vibratory movements.

8. Reduction of dissolved oxygen in the surrounding water caused an increase in the frequency of the vibration periods, low quantities—below 1.0 c. c. per liter—tended to produce constant vibration.

9. Immobilization produces an inert condition in which the larva may exist for 80 or more hours and recover when returned to the natural conditions.

10. Available evidence indicates that the principal if not the sole function of these vibratory movements is to insure the continued contact of the respiratory surfaces with a changing supply of amply oxygenated water.

LITERATURE CITED.

Buckler, Wm. 1875. On the Larva and Habits of Paraponyx stratiotalis. Entomologists Monthly Magazine, 12: 160-163.

Miall, L. C. 1895. The Natural History of Aquatic Insects. London. 395 pp., 116 figs.

Welch, P. S. 1916. Contribution to the Biology of Certain Aquatic Lepidoptera. Ann. Ent. Soc. Am., 9: 159-190, 3 pls.

1922. The Respiratory Mechanism in Certain Aquatic Lepidoptera. Trans. Am. Micr. Soc., 41: 29-50, 2 pls.

1924. Observations on the Early Larval Activities of Nymphula maculalis Clemens (Lepidoptera). Ann. Ent. Soc. Am., 17: 395-402.

A FEW WESTERN APHIDS WITH DESCRIPTIONS OF THREE NEW SPECIES.*

GEORGE F. KNOWLTON,
Utah Agricultural Experiment Station.

Aphis gregalis n. sp.†

This aphid is common in Utah, feeding in great numbers on the tip-growth, leaves, and flower stalks of rabbit brush, *Chrysothamnus viscidiflorus* and *C. parryi*. The continuous feeding of the large colonies of this aphid results in the distortion of the leaves on the ends of branches, which distortion affords partial protection and concealment for the colonies. The apical growth, flower heads, and their supporting stems are also partially stunted and slightly distorted.

The stem mothers are usually good-sized aphids, with slightly wider abdomens than the summer forms. The body is bluish-green and has a pruinose covering which is present on all of the apterous generations. The summer apterous females are often smaller than the spring forms, mature individuals in some crowded colonies measuring only 1.2 mm. in length. The apterous females usually have black blotches of various sizes on the abdomen. During spring and early summer these may vary from a few patches in front of the cornicles to broad bands on all abdominal and thoracic segments (Fig. A). During late summer, the yellowish-green to bluish-green females may have only a few dark blotches. However, blotches are entirely absent on most females during the fall. The males are small and brownish-black. Males and oviparous females become abundant during October. The females attach large numbers of the eggs to the scales at the base of the flowers and to other parts at the tips of the twigs.

This aphid resembles a form attacking the sunflower *Helianthus annuus*, but differs in several important respects; several attempts to colonize this species on the sunflower have failed.

This aphid is commonly attended by great numbers of ants (usually *Formica rufa*). A few predators and parasites attack the aphid colonies, syrphid larvæ being most commonly present.

Stem mother.—Color bluish-green covered with grayish pruinose; size 1.8 to 2.5 mm. long, and broadly oval; irregular black blotches or stripes usually present on abdomen; rostrum reaching third coxæ;

---

*Contribution from Department of Entomology, Utah Agricultural Experiment Station. Approved for publication by Director, February 10, 1928.

†The writer wishes to thank Professor O. W. Oestlund, Dr. C. P. Gillette, and Miss M. A. Palmer for suggestions concerning this form.

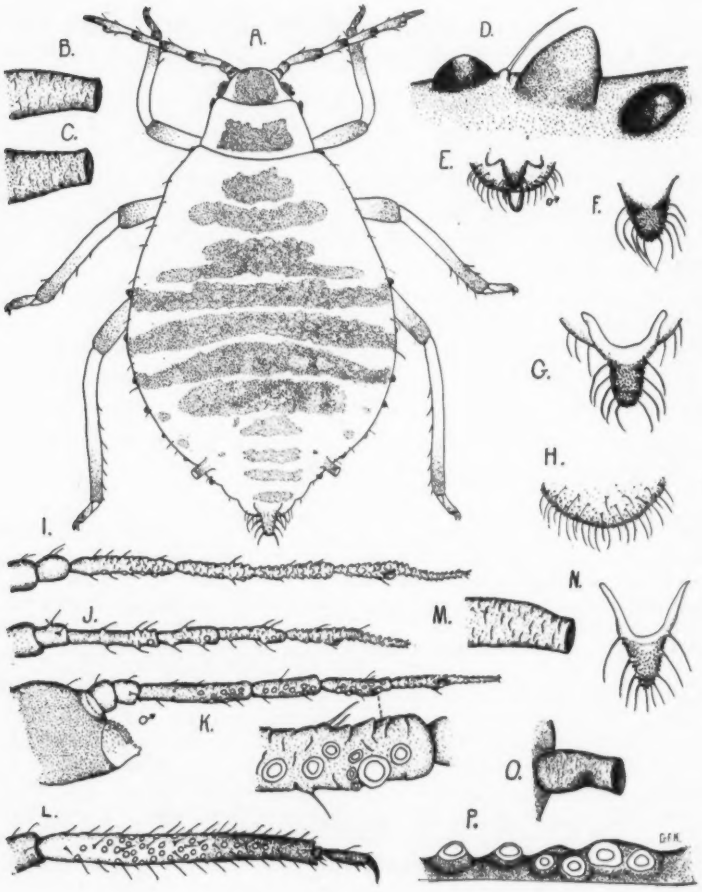


Fig. 1. *Aphis gregalis.*

A, Apterous viviparous female; *B*, *C*, cornicles of apterous females; *D*, first lateral tubercle on abdomen and black raised spots along sides of oviparous female; *E*, posterior end of male; *F*, cauda of oviparous female; *G*, cauda and anal plate of apterous female; *H*, anal plate of oviparous female; *I*, antenna of alate female; *J*, antenna of apterous female; *K*, head and antenna of male; *L*, hind tibia of oviparous female, showing sensoria; *M*, cornicle of stem mother; *N*, cauda of alate female; *O*, cornicle of alate female; *P*, sensoria from antennal III of alate female, much enlarged.

antennæ dusky and armed with a few prominent sensillæ*; antennal III, 0.23 to 0.31 mm. long and usually without sensoria; IV, 0.13 to 0.17 mm., occasionally with one distal sensorium; V, 0.13 to 0.15 mm.; VI, 0.11 + 0.15 to 0.12 + 0.16 mm.; legs short, hind tibia 0.8 mm. long; cornicles black, 0.17 to 0.2 mm. long, tapering very slightly toward distal end; cauda black, rather short, with a very slight constriction near base; anal plate black, rounded.

Apterous vivipara.—Color, bluish-green to yellowish-green, with a pruinose covering; size 1.2 to 1.85 mm. long; body broadly oval, with dark spots or blotches usually present on the back; rostrum reaching third coxæ; head rounded in front, with slight antennal tubercles; antennæ black, extending two-fifths the length of the body, and armed with a few prominent sensillæ; antennal III, 0.18 to 0.2 mm. long, armed with 0 to 3 circular sensoria toward the distal end of the segment; IV, 0.1 to 0.13 mm., with 0 to 1 distal sensorium; V, 0.11 to 0.12 mm.; VI, 0.09 + 0.12 to 0.1 + 0.13 mm.; legs short, hind tibia, 0.67 mm. long; lateral tubercles well developed on most abdominal segments, as well as on the first two thoracic segments; cornicles black, 0.17 mm. long, slightly bent downward; cauda black, almost conical, with a very slight constriction near the base; anal plate black, rounded.

Alate vivipara.—Size 1.4 to 1.7 mm. long; rostrum reaching third coxæ; head and thorax black; antennæ dusky and armed with a few conspicuous sensillæ, antennal III, 0.25 mm. long and armed with 2 to 7 round sensoria in a regular to scattered row; IV, 0.12 to 0.15 mm., with 1 to 2 sensoria on the distal half of the segment; V, 0.12 to 0.15 mm.; VI, 0.1 + 0.15 mm.; legs rather short, hind tibia 0.75 mm. long; front wings with media twice branched; hind wings with both media and cubitus present; abdomen bluish-green to dusky, with slight pruinose covering; lateral tubercles on thorax and abdomen; cornicles short, black, slightly bent, and 0.12 mm. long; cauda black, conical to very slightly constricted near the base; anal plate black, rounded.

Ovipara.—Color greenish-red to reddish-brown with a pruinose covering; size 1.4 to 1.7 mm. long; rostrum reaching third coxæ; head and antennæ dusky; antennal III, 0.15 to 0.19 mm. long, sensoria lacking; IV, 0.09 to 0.1 mm.; V, 0.1 mm.; VI, 0.09 + 0.11 to 0.1 + 0.12 mm.; legs short, hind tibia 0.41 mm. long, swollen for most of its length, and armed with numerous sensoria; wingless; abdomen more narrow and elongate than in the apterous viviparous females; lateral tubercles present but less conspicuous than in the summer generations; dark slightly raised spots present on sides of abdomen; cornicles black, 0.1 mm. long, slightly bent; cauda black, short, almost conical, with a slight constriction near the base; anal plate black and broadly rounded.

Eggs.—0.7 mm. long, light greenish when first cemented to scales and other distal parts of the twigs, later turning to a shining black color.

---

*Antennal III very often fails to divide, leaving a longer antennal III, and making one or both antennæ on some individuals five-segmented. This most commonly occurs in the oviparous females, but occurs frequently in all other forms.

Male.—Color reddish-brown to dusky; size 0.92 to 1.15 mm. long; rostrum reaches beyond third coxæ; head and antennæ black; antennal III, 0.2 mm. long, somewhat swollen and armed with 10 to 23 round sensoria; IV, 0.11 to 0.16 mm., with 6 to 17 sensoria; V, 0.11 to 0.15 mm., with 5 to 13 secondary sensoria in addition to the primary sensorium; VI, 0.1 + 0.13 mm.; legs short, hind tibia 0.53 mm. long; wingless; cornicles small, black, 0.07 mm. long; cauda short, black, cone-shaped, with a very slight constriction near the base; anal plate black, broadly rounded.

This aphid has been collected in Utah from Amalga, Blacksmith Fork Canyon, Hyrum, Kanosh, Leeds, Lehi, Logan, Mona, Santaquin, Smithfield, and Trenton.

In addition to the collection of the writer, cotypes are in the collections of the U. S. National Museum and Utah Agricultural Experiment Station.

Aphis bonnevillensis n. sp.*

A small blue-green aphid is common in many parts of Utah, attacking the leaves, flower spikes and new tip-growth of greasewood, *Sarcobatus vermiculatus* (Hook) Torr. The wingless females are most common and are so much the color of the fleshy leaves that they are often overlooked unless a careful examination is made. The wingless females are usually very abundant in the spring, and many hundreds of these short-legged forms may be found on a single twig. They usually lie very quietly against the fleshy leaves of the plant. During the summer, the colonies of this gregarious aphid often are much reduced by the larvæ of aphid lions and syrphids, as well as by lady-bird beetles and internal parasites. Ants are seldom found associated with this aphid.

The spring migrants were fairly abundant at Hinckley, Oasis, and Delta by May 4, 1927, and were taken at Axtell, Elsinore, Milford, Richfield, Salina, Sigurd, and Venice later in the week. The stem mothers were also numerous at this time. Collections have also been made at Aurora, Benson, Gunnison, Hooper, Lynndyl, and Trenton.

Stem mother.—Blue-green; moderately large, size 2 to 2.7 mm. long and 1.25 to 1.4 mm. across the abdomen; sensillæ on body and antennæ short, spine-like and rather scarce; antennal tubercles moderately developed; antennæ about half the length of body, five-segmented and

*The writer wishes to thank Dr. P. W. Mason, of the U. S. Bureau of Entomology, for his opinion on this form.

without secondary sensoria; antennal III, 0.3 to 0.33 mm. long, IV, 0.15 mm.; V, 0.1 + 0.08 mm.; legs short, hind tibia 0.75 mm. long; abdomen broad, but not so highly arched as in later generations of wingless females; cornicles 0.15 mm. long, cylindrical or occasionally slightly swollen, and with a constriction before the flange; cauda rather conical, dusky, with hairs irregularly distributed and fairly numerous.

Alate vivipara.—Head and thorax shiny black; size 1.3 mm. long; rostrum reaching third coxæ; head, body and antennæ with but few short, spine-like sensillæ; antennal tubercles undeveloped; antennæ

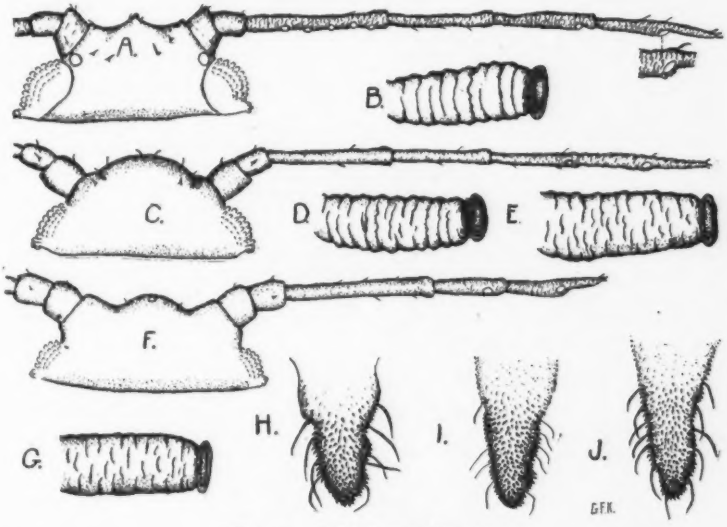


Fig. 2. *Aphis bonnevillensis.*

A, Head and antenna of alate female; *B*, cornicle of alate female; *C*, head and antenna of apterous female; *D*, cornicle of alate female; *E*, cornicle of apterous female; *F*, head and antenna of stem mother; *G*, cornicle of stem mother; *H*, cauda of apterous female; *I*, cauda of stem mother; *J*, cauda of alate female.

about three-fifths the length of the body; antennal III, 0.2 to 0.25 mm. long and with 4 to usually 5 circular sensoria in a row; IV, 0.18 mm. and without sensoria; V, 0.16 mm.; VI, 0.12 + .01 mm.; legs rather short, hind tibia 0.9 mm. long; fore wings with media twice branched; hind wing with both media and cubitus present; abdomen green and not arched as in apterous forms; cornicles black, 0.14 mm. long, cylindrical or very slightly swollen toward distal end, and with a constriction before the flange; cauda black, conical, and occasionally approaching what might be a slight constriction near the base.

Apterous vivipara.—Blue-green, very much the color of the leaves on which it feeds; size rather small, 1.45 mm. long; width of abdomen

0.9 mm.; beak nearly reaching hind coxæ; short, spinelike sensillæ scarce on body and antennæ; moderately developed antennal tubercles; antennæ rather short, reaching nearly two-thirds the length of the body; antennal III, 0.27 to 0.3 mm. long and without sensoria; IV, 0.2 mm.; V, 0.18 mm.; VI, 0.15 + 0.1 mm.; legs short, hind tibia 0.83 mm. long; abdomen highly arched and smooth; cornicles 0.17 mm. long, cylindrical or very slightly swollen near base and with a constriction before the flange; cauda rather cone-shaped.

It seems most logical to place this species in the genus *Aphis*, although it differs in minor respects from the commonly accepted definition of the genus.

In addition to the collection of the writer, cotypes are in the collections of the U. S. National Museum and the Utah Agricultural Experiment Station.

Pemphiglachnus gen. nov.

Antennæ six-segmented, armed with broadly oval sensoria and inserted in depressions on the lower margin of the head; forewings with the media once branched; radial sector arising well back toward the base of the stigma, giving a rather long stigmal cell; hind wings with both media and cubitus present; abdomen armed with long, curved hairs; cornicles reduced to pores; cauda broadly rounded; anal plate quadrangular to broadly rounded.

Type, *Pemphiglachnus kaibabensis* Knowlton. This genus probably belongs in the supertribe Phyllaphidea, near *Tamalia* (Pergande) Baker.

Pemphiglachnus kaibabensis n. sp.*

This aphid was collected in the Kaibab Forest, Arizona, on July 12, 1925. The winged form was feeding on the needles of blue spruce, *Picea pungens*, near Bright Angel Point at the Grand Canyon.

The head, thorax, and wings are quite generally Pemphigean, while the cauda, anal plate and long, curved hairs over the abdomen suggest a Lachnean relationship.

Alate vivipara.—Size 2.5 mm. long; head and thorax black, armed with a few moderately long, slightly curved hairs; rostrum reaching second coxæ; antennæ black, inserted in depressions under the margin of the head; antennal III, 0.34 mm. long, with 9 or more broadly oval sensoria; IV, 0.17 mm., with one prominent distal sensorium; V, 0.2 mm.; VI, 0.21 (0.17 + 0.04) mm.; legs black, of moderate length, hind tibiæ

* The writer wishes to thank the Professor O. W. Oestlund and Mr. A. C. Maxon for their opinion concerning this form.

1.1 mm. long; front wings with slight shading at margins of the dusky veins; radial sector long and curved, inserted well back toward the base of the stigma, making a quite long stigmal cell; media once branched; the three veins on the hind wings arising close together, giving a tridentate appearance; abdomen green and armed with numerous long, curved hairs; cornicles reduced to pores; cauda broadly rounded; anal plate quadrangular to broadly rounded.

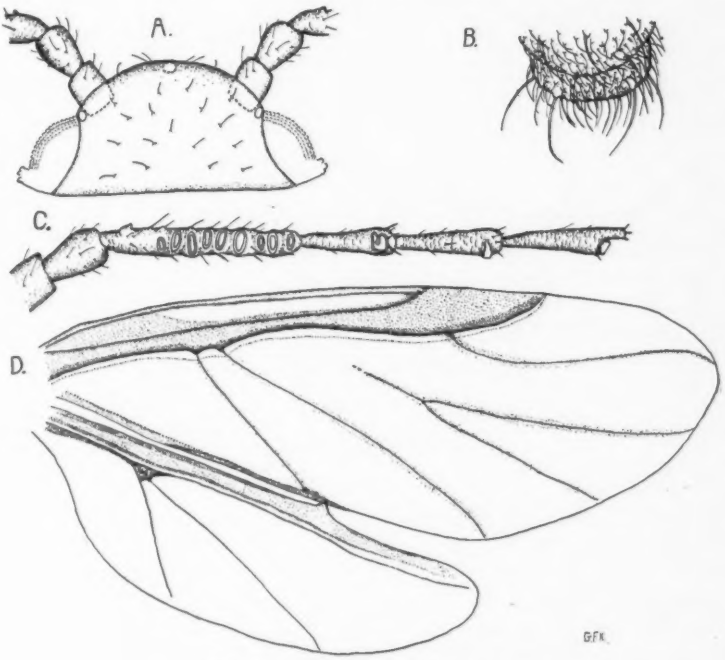


Fig. 3. *Pemphiglachnus kaibabensis*
A, head; *B*, cauda and anal plate; *C*, antenna; *D*, wings.

Mindarus abietinus Koch.

This aphid was doing considerable damage to white fir, *Abies concolor* (Gord.) Parry, and to black balsam or alpine fir, *Abies lasiocarpa* (Hook) Nutt., in northern Utah during the spring and early summer of 1925. During late June and early July, both pupal nymphs and alates were extremely numerous in the canyons around Salt Lake City, so that the clothing and

lunches of picnickers in the conifer groves became covered with great numbers of these winged aphids. When an infested twig was disturbed, a shower of honeydew would fall. The needles on the tip growth were heavily infested with the pupal nymphs, and considerable distortion of the needles occurred. Larvæ of syrphid flies were abundant, but seemed to have little effect on the great numbers of aphids.

This aphid has been comparatively scarce in Utah during 1926 and 1927, and probably will be of little economic importance except during occasional years very favorable to aphid development.

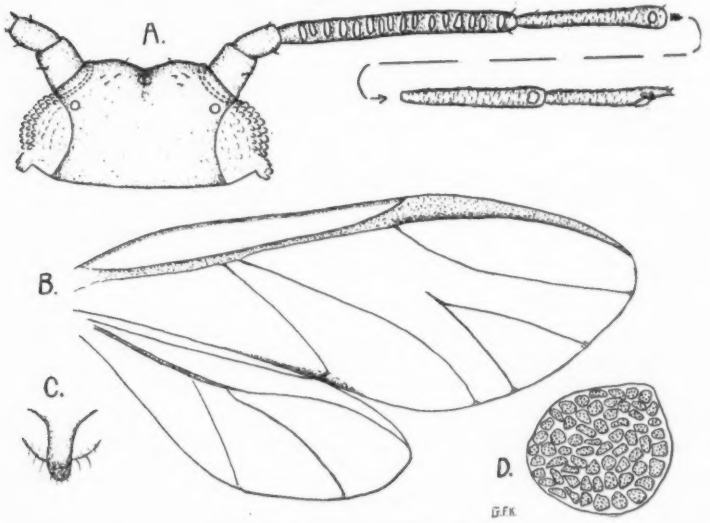


Fig. 4. *Mindarus abietinus* Koch.
A, head and antenna of alate female; *B*, wings of alate female; *C*, cauda of alate female; *D*, waxplate of pupal nymph, from side of abdomen.

Alate vivipara.—Size 2.3 to 2.6 mm. long, rostrum reaching third coxæ; head black, with antennæ attached under the margin of the head in a slight depression; antenna black, six-segmented and armed with a few short spinelike sensillæ; antennal III, 0.4 to 0.46 mm. long and armed with 13 to 19 broadly oval sensoria; IV, 0.22 to 0.26 mm. with one prominent distal sensorium; V, 0.26 to 0.29 mm.; VI, 0.15 + 0.05 to 0.21 + 0.07 mm.; thorax black; legs moderately long; front wings with a long, narrow stigma which nearly reaches the tip of the wing;

radial sector arises at the base of the stigma or back of it, and extends most of its length in a rather straight line to the margin of the wing; media once-branched; abdomen green, slightly pruinose; cornicles inconspicuous and pore-like; cauda elongate; anal plate broad.

Pupal nymph.—Size 2.3 to 2.5 mm. long; color whitish to yellow with pruinose covering; the numerous wax plates are more heavily chitinized than the rest of the body wall and composed of numerous small wax pores.

This aphid has been collected from American Fork Canyon, Big Cottonwood Canyon, Brighton, Cedar Breaks (elevation, 10,000 feet), Cold Creek Canyon, Emigration Canyon, Mill Creek Canyon, Mount Henry, Pinecrest, and Provo Canyon, Utah. It has been collected also in Emmigration Canyon, Idaho, and in the Kaibab Forest, Arizona.

Stegophylla quercicola (Baker) Oestlund.

This aphid has been taken on scrub oak, *Quercus gambellii*, from American Fork Canyon, Cedar Canyon, Cedar City, Ogden, and Zion National Park, in Utah. This aphid is often found feeding in large numbers on the underside of the oak leaves, the aphids being hidden under an abundance of white, flocculent material.

GENUS **Anoecia** Koch.

Anoecia querci (Fitch).

This form is quite common in Utah, occurring on dogwood (*Cornus* sp.) and grasses. It is often taken on other plants on which it alights during periods of migration.

Stem mother.—Size 1.2 mm. long, with broad abdomen; body blackish and armed with fewer hairs than in the winged forms; antenna five-segmented; antennal III, 0.14 to 0.17 mm. long and without sensoria; IV, 0.067 mm.; V, 0.06 + 0.05 mm.

Spring migrant.—Size 1.2 mm. long; rostrum reaching third coxæ; head and antennæ black and armed with numerous long, curved hairs; antennal III, 0.19 mm. long and armed with 2 to 3 oval sensoria; IV, 0.085 mm., and with one distal sensorium; V, 0.087 mm.; VI, 0.09 + 0.06 mm.; thorax black; legs black, of moderate length and armed with numerous long hairs; front wings with once-branched media and short, broad stigma; cornicles on broad hairy cones; cauda rounded and armed with numerous long hairs; anal plate broad.

Fall migrant.—Size 2.0 mm. long; rostrum extends to or slightly beyond second coxæ; head and appendages black and armed with numerous long, rather slender hairs; antennæ six-segmented and inserted

under margin of head; antennal III, 0.25 mm. long and armed with five or six prominent oval sensoria; IV, 0.12 mm., with one or two round sensoria; V, 0.12 mm.; VI, 0.11 + 0.07 mm.; thorax black; legs of moderate length; front wings with one branched media and broad, short stigma; cornicles mere rings on broad hairy cones; cauda rounded and armed with numerous long hairs; anal plate broad.

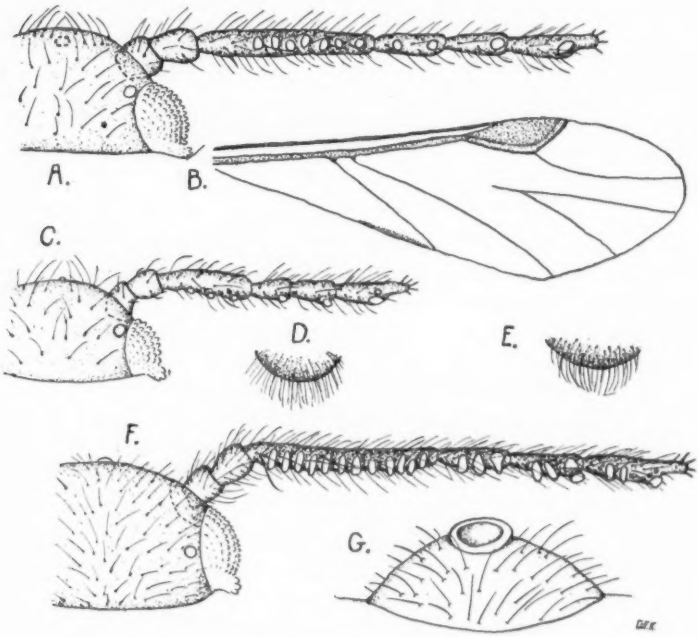


Fig. 5. *Anoecia querci* (Fitch).
A, head and antenna of fall migrant; *B*, front wing of fall migrant; *C*, head and antenna of spring migrant; *D*, anal plate of spring migrant; *E*, anal plate of fall migrant. *Anoecia corni* (Fab.). *F*, head and antenna of fall migrant; *G*, cornicle of fall migrant.

This aphid has been collected by the writer from Brigham Canyon, Brigham City, Honeyville, Logan, and Salt Lake City, Utah, as well as from Minneapolis and St. Paul, Minnesota, and Columbus, Ohio.

Anoecia corni (Fab.) Koch.

The writer has not collected this form in Utah. The drawings are from specimens taken in Ohio and given to show the difference in antennal sensoria between *querci* and *corni*.

THE COLEOPTERA OF ZION NATIONAL PARK, UTAH.*

By Vasco M. Tanner, Ph. D.

It has been the writer's privilege to collect insects for a few days each summer for the past eleven years in the beautiful canyon, Zion National Park. This park is one of the nations most recently established playgrounds and holds many attractions for the student of the great out-of-doors. So far as the writer knows this is the first attempt that has been made to publish a report on the insect life of this region. In this paper 246 species from 39 families are listed; four of the species are new to science.

Family Cicindelidæ.

Cicindela tranquebarica Hbst. Along the river, May-September.
Cicindela tranquebarica Var. **horiconensis** Leng. Found associated with **tranquebarica** and **oregona.**
Cicindela vibex Var. **inyo** Fall.
Cicindela vibex Var. owena Fall. These two forms of **vibex** seem to be only seasonal variations, as Fall (1917) suggests, since I have taken the "brilliant green" **inyo** in May on the sand-bars along the river and the "black" **owena** in August.
Cicindela longilabris Var. **laurenti** Schp. Collected on the mesa above the canyon at an elevation of 7,000 to 8,000 feet.
Cicindela oregona Lec. Common.
Cicindela punctulata Var. **chihuahuae** Bates. Common about the "water-holes" on the mesa of the park.

Family Carabidæ.

Calosoma semilaeve Lec. On the floor of the canyon.
Nebria sp.?
Dyschirius sphaericollis Say. In damp gravel near river.
Bembidion bifossulatum (Lec.).
Bembidion bifasciatum (Mots.).
Bembidion acomanum Csy.
Bembidion consanguineum Hayw.
Bembidion lucidum (Lec.).
Bembidion indistinctum Dej.
Bembidion tetracolum Say. All the species of **Bembidion** listed here were collected along the river and small streams. **Indistinctum** and **acomanum** are common species.

---

*Contribution No. 15 from the Department of Zoology and Entomology, Brigham Young University, Provo, Utah.

Tachyura audax (Lec.). Near the river, not common.
Tachyura obesulus (Lec.).
Tachys vorax Lec. Only two specimens collected.
Pterostichus protractus Lec.
Pterostichus spraguei Lec. This is one of the rare and interesting carabids collected in the Park.
Pterostichus adoxus (Say). One of the common species along the Virgin River of Utah.
Parargutor lustrans (Lec.). Collected under stones.
Bradytus specularis Csy. Collected in the dead leaves and rocks along the trails of the canyon.
Celia obligata Csy.
Celia musculus (Say). One of the common carabids of the Park.
Rhadine myrmecodes Horn.
Platynus brunneomarginatus Mann. I have collected but one specimen of this species in Zion Park.
Platynus (Colpodes) **rufiventris** Van Dyke. I collected several specimens of this species near the Public Camp grounds of the Park.
Galerita lecontei Dej.

Axinopalpus utahensis, new species. Fig. 1.

Humeral pale maculation extended posteriorly and sharply defined; antennæ fusco-testaceous throughout and about as long as the elytra; dorsal aspect black, the humeral pale mark extending through three-fourths of the elytra; outer elytral margins pale with long anterior and posterior setæ; under surface and legs ochraceous, except the posterior sternites which are black; head slightly narrower than the prothorax; eyes large and prominent; prothorax smooth and polished, only slightly wider than long, the basal lateral right angles prominent; the median stria deep anteriorly but disappearing posteriorly; elytra with six rows of feeble striæ; one fifth longer than wide; aedeagus (Fig. 1) long and slender with a blunt point and barbs. Length, 3 to 3.1 mm., width, 1.1 to 1.2 mm.

Col. Casey (1920) reviewed this genus and described four new species in his IX Memoir. According to his arrangement of the eight species *Axinopalpus uthaensis* is closely related to and should follow *Axinopalous californicus* Mots. Figures 2 and 3 show the genitalia of *Axinopalpus biplagiatus* Dej. A most interesting prothoracic tibial structure is present in all the species of this genus. In an attempt to ascertain if this was confined to this and closely related genera I find that many groups such as *Bembidion* have an almost identical structure. In a great many respects *Axinopalpus* and *Bembidion* are morphologically alike.

Type specimen a male (No. 22) and three male paratypes in my collection. Specimens collected at Springdale, (near the entrance to Zion Park), Saint George, and Utah Lake, Utah.

Brachinus minutus Harris.
Brachinus costipennis Mots.
Brachinus sp.? I am making a careful study of this group. At the present time it is almost impossible to accurately determine the species of this genus.
Chlaenius sericeus Forst. Common.
Harpalus caliginous (Fab.).
Harpalus amputatus Say.
Harpalus pennsylvanicus DeG. A common species.
Selenophorus sp.?
Discoderus amoenus Lec.
Stenolophus conjunctus (Say). Rare.

FAMILY OMOPHRONIDÆ.

Omophron obliteratum var. **utense** Csy. Common along the river.

FAMILY DYTISCIDÆ.

Deronectes striatellus (Lec.). Common in the pools of the side canyons.
Agabus perplexus Shp. Very common.
Agabus seriatus (Say).
Agabinus glabrellus (Mots.). Rare.
Rhantus binotatus (Harr.). A common and interesting species.
Rhantus anisonychus Cr.
Dytiscus marginicollis Lec. Rare.

FAMILY GYRINIDÆ.

Gyrinus plicifer Lec. Common, especially at Emerald Pool.

FAMILY HYDROPHILIDÆ.

Hydrous triangularis (Say). Two specimens taken at Birch Creek.
Tropisternus ellipticus (Lec.). Specimens taken at Emerald Pool.
Enochrus fucatus (Horn). In ditches near the Lodge.
Cymbiodyta dorsalis (Mots.). Common.
Cymbiodyta punctatostriata (Horn). Only two specimens collected.
Sphaeridium scarabaeoides (L.). Taken near the Camps.

FAMILY SILPHIDÆ.

Necrophorus marginatus Fab. Several specimens collected.
Necrophorus guttula Mots.
Silpha lapponica Hbst.
Silpha ramosa Say.

FAMILY STAPHYLINIDÆ.

Lispinus obscurus Lec. Under bark of **Populus fremontii.**
Omalium plagiatum Mann.
Stenus sp.?
Lathrotaxis rubricollis Csy. Under stones near the River.
Hesperolinus alticola Csy (?). Two specimens collected.

Neobisnius paederoides (Lec.). In debris near the River.
Philonthus furvus Nordm.
Ontholestes cingulatus (Grav.).
Creophilus maxillosus var. **villosus** (Grav.).
Tachinus agilis Horn. Collected in debris near the River.

FAMILY HISTERIDÆ.

Hololepta populnea Lec. Under bark of dead trees.
Hister semiruber Csy. Collected at the Public Camp.
Platysoma depressum Lec. Under bark of dead trees.
Saprinus lugens Er.

FAMILY LYCIDÆ.

Calopteron sp.?
Lycaina discoidalis Horn. Taken on vegetation by sweeping with a net.

FAMILY LAMPYRIDÆ.

Lucidota fenestralis (Melsh.). Collected on sunflowers and ragweeds.

FAMILY CANTHARIDÆ.

Podabrus tomentosus (Say). Taken by sweeping with net.
Podabrus sp.?
Cantharis sp.?
Malthodes sp.? Several of these species I have been unable to get determined because of only one specimen of each species.

FAMILY MELYRIDÆ.

Collops bipunctatus Say. On sunflower blossoms and weeds.
Collops vittatus (Say).
Attalus sp.?

Trichochrous zionicus New Species. Fig. 4 and 5.

Form elongate and rounded; color black, the polished surface shines through the thick whitish recumbent pubescence; prothorax a fourth wider than the head; vertex front and genæ of head cloth with pubescence; antennæ rubinous, 0.1 mm. longer than the medium line of the prothorax; ventral aspect blackish except the legs which are pale; venter and legs densely pubescent; prothoracic tibia long and slender with setæ on distal two thirds Fig. 5; prothorax transverse, about a fourth wider than long; sides with short even lateral cilia or fringe; basal angles of pronotum well formed and obtuse; sides evenly arcuate and slightly sinuate before the angles; apical angles rounded; pubescence of pronotum about evenly distributed being most sparse along the posterior medium line; elytra oblong-oval, broadly rounded at apex; more than a half longer than wide; a few suberect hairs along the sides; pubescence and punctures evenly distributed.

The genitalia Fig. 4 are distinctly different from **T. antennatus** Fig. 7; **T. laticollis** Fig. 8; **T. nubilatus** Fig. 9; and **Eudasytes hirsutus** Blais. Fig 10.

Length 3 mm., width 1.2 mm.

Type locality Zion National Park, Utah.

Type female No. 23 and three paratypes in my collection.

Trichochrous zionicus is most closely related to *T. antennatus* and should follow it in Casey's list (1895). *T. zionicus* may be separated from *T. antennatus* as follws:

Body stouter, densely pubescent.
Cilia of pronotum longer, not forming a regular fringe..*T. antennatus* Mots.
Cilia short, forming a regular fringe.....*T. zionicus* Tanner

The prothoracic tibia, Fig. 5, of *T. zionicus* may be used to separate it from *T. antennatus*, Fig. 6.

I desire to thank Dr. Frank E. Blaisdell, who furnished specimens of several species and genera used in this study.

Listrus interruptus Lec. Taken in the flowers of **Opuntia** sp.

FAMILY CLERIDÆ.

Cymatodera latefasica Schffr.
Cymatodera undulata var. **brunnea** Spin.
Enoclerus spinolæ Lec.
Trichodes ornatus Say. Collected in **Argemone rotundata** and **Helianthus fascicularis.**

FAMILY OEDEMERIDÆ.

Copidita obscura (Lec.).
Asclera excavata Lec.

FAMILY MORDELLIDÆ.

Mordella albosuturalis Lilf. Taken in blossoms of **Opuntia** sp. and **Pentstemon palmeri.**
Anthobates sp.
Anaspis atrats Champ.
Anaspis collaris Lec. Both species of **Anaspis** taken in **Opuntia** sp.

FAMILY MELOIDÆ.

Pyrota mylabrina Chev. Common on **Gutierrezia sorothræ** in August and September.
Epicauta maculata (Say).
Lytta magister Horn. Taken on **Chrysothamnus paniculatus.**
Zonitis flavida Lec. Common on **Helianthus fascicularis.**
Nemognatha apicalis Lec.
Nemognatha punctipennis Lec.

FAMILY PEDILIDÆ.

Pelilus incondpicuus (Horn).

FAMILY ANTHICIDÆ.

Notoxus sp.
Anthicus nitidulus Lec.

FAMILY PLASTOCERIDÆ.

Euthysanius blaisdelli Tanner. Type locality.

FAMILY ELATERIDÆ.

Aeolus livens (Lec.).
Ludius maurus (Lec.).
Ludius inflatus (Say).
Dolopius lateralis var. **subustus** Lec.
Elater horni Cand.
Melanotus communis (Gyll.).
Cardiophorus nevadensis Bl.
Cardiophorus tenebrosus Lec.
Cardiophorus tumidicollis Lec.
Heteroderes sordidus (Lec.).

FAMILY MELASIDÆ.

Anelastes druryi Kby. Taken around camp fires in the evenings.

FAMILY BUPRESTIDÆ.

Acmaeodera sparsa Horn. Taken in August on the blossoms of several different species of plants.
Acmaeodera hepburni Var.?
Acmaeodera connexa Lec. Common in May.
Acmaeodera variegata Lec. Common.
Acmaeodera vandykei Fall. Rare.
Hippomelas juniperina Wickh.
Buprestis aurulenta L. Taken in May on the East Mesa.
Buprestis viridisuturalis N. & W. Taken in **Populus fremonti.**
Buprestis langi (Mann.).
Anthaxia aeneogaster Cast. Taken on the blossoms of **Rosa** sp.
Chrysobothris quadrilineata Lec. Taken around **Pinus ponderosa** on the East trail.
Argilus politus (Say).

FAMILY DERMESTIDÆ.

Dermestes marmoratus Say.
Dermestes vulpinus Fab.
Attagenus elongatulus Csy. Taken in **Opuntia** blossoms.
Anthrenus sp. Taken in flower blossoms.

FAMILY OSTOMIDÆ.

Temnochila virescens var. chlorodia (Mann.).
Tenebroides muritanicus (L.).

FAMILY NITIDULIDÆ.

Carpophilus pallipennis (Say). In blossoms of **Opuntia** sp.

FAMILY MONOTOMIDÆ.

Leptipsius striatus (Lec.). Under the bark of **P. fremonti.**

FAMILY CUCUJIDÆ.

Silvanus planatus Germ.
Laemophloeus nitens Lec. Both of these species taken under the bark of dead cottonwoods.

FAMILY COCCINELLIDÆ.

Hippodamia lunato-maculata var. **apicalis** Csy.
Hippodamia sinuata var. **complex** Csy.
Hippodamia convergens Guer. Common.
Hippodamia convergens var. **politissima** Csy.
Hippodamia lecontei Muls.
Hippodamia Lecontei var. **uteana** Csy.
Olla abdominalis (Say). Rare.
Adalia frigida var. **humeralis** (Say). Rare.
Anatis lecontei Csy. Taken on **P. ponderosa** on the east mesa.
Ceratomegilla fuscilabris (Muls.). One specimen taken at Springdale in August.
Epilachna corrupta Muls. Common in Springdale at the entrance to the park.

FAMILY ALLECULIDÆ.

Hymenorus prolixus Csy. Rare, only one specimen collected.

FAMILY TENEBRIONIDÆ.

Telabis serrata Lec. Rare.
Hylocrinus delicatulus Csy. Seems to be rare.
Steriphanus hilaris Csy.
Lobometopon fusiforme (Csy.). Common on Milkweeds.
Triorophus laevis Lec. Taken on the dry hillsides under rocks.
Zopherodes tristis (Lec.).
Eleodes carbonaria, form interstitialis Blais. A common species in the park.
Eleodes obsoleta var. **porcata** Csy.
Eleodes pilosa Horn. Taken on the east rim trails.
Eleodes obscura var. **sulcipennis** Mann. Very common.
Eleodes hispilabris var. **sculptilis** Blasi.
Eleodes tenebrosa Horn. Seems to be rare in the park.
Eleodes pimelioides var. **patruelis** Blais.
Eleodes negrina Lec. Common.
Eleodes dissimilis var. **nevadensis** Blais.
Eleodes parawana var. **mimica** Blais. Rare.
Embaphion elongatum Horn. Common under logs.
Embaphion glabrum Blais.
Eusattus dubius Lec.
Coniontis opaca Horn. Common in May.
Blapstinus dilatatus Lec.
Blapstinus sulcatus Lec. Common.
Iphthimus serratus var. **sublaevis** Bland. Rare, only one specimen taken.

Coelocnemis punctata Lec. This is the common Coelocnemis of the park.
Coelocnemis tanneri Blais. Type locality. Paratypes in my collection. Specimens taken in debris near the river.
Coelocnemis sulcata Csy.
Tenebrio picipes Hbst.

FAMILY ANOBIIDÆ.

Vrilletta expansa Lec. Rare.
Xyletinus sp.

FAMILY SCARABAEIDÆ.

Aphodius rubidus Lec.
Ataenius abditus (Hald.). Rare.
Trox gemmulatus Horn.
Diplotaxis sp. I have several species of this genus but have been unable to get them determined.
Polyphylla diffracta Csy. Specimens taken in June and July in various parts of the valley of the park.

Polyphylla uteana New Species. Fig. 12.

Body stout, oval, longer than *diffracta;* color black and shining; pronotum without erect hairs, very sparse whitish vestiture; vertex and clypeus with coarse punctures, the vertex without erect hairs, the clypeus with sparse whitish scales, slightly denser on the reflexed edge, which is straight; last palpal joint three and a half times as long as wide, without a flattened outer area, but with a coarsely yet sparsely punctate surface; antennal club 5 mm. long; prothorax without any erect hairs, with coarse punctures not so dense at the posterior margin; the scales of the median line poorly developed and the basal sublateral vittæ are practically absent; scales along the margins sparse, and totally absent at the highest point of the prothorax between the median line and the sublateral vittæ; elytra three times as long as wide and one and a third times as wide as the prothorax; suture devoid of a vitta of whitish scales; the lines of each side of the suture wanting; only a few whitish scales scattered over the elytra; pygidium cloth with small scales; the intermediate tarsi .5 mm. shorter than the tibia; anterior tibia unidentate in the male. Length 24.2 mm.; width 12 mm.

Type locality Kanab, Utah, about thirty miles southeast of Zion Park.

Holotype male No. 25 in my collection. Collected by Anson Call, Jr., and D. Irvin Rasmussen, July 13, 1927.

Polyphylla rufescenta New Species. Fig. 13.

Body stout oval and oblong; color reddish with a whitish vestiture; vertex and clypeus punctured and cloth with many recumbent brownish hairs, the clypeus with sparse whitish scales, denser near the reflexed margin, which is slightly arcuate in outline, the angles obtuse; vertex black in color while the clypeus is reddish; last palpal segment three

and a third times as long as wide, sparsely punctate and with a small flat area; antennal club greatly curved, 9.2 mm. long; prothorax without any erect hairs, coarsely, but irregularly punctate; medium line with regular whitish scales, the subbasal vittæ well developed, whitish scales sparse on other parts of the prothorax; elytra 2.4 times as long as wide and one and a third times as wide as the prothorax; suture with a well developed vitta of whitish scales, the three discal lines on each side consisting of closely set scales, the second row being 1 mm. wide; the pygidium is cloth with whitish scales closely set; anterior tibia is entirely edentate; the tarsi of the intermediate legs are missing. Length 36 mm.; width 16 mm.

Type locality, Saint George, Utah, about 50 miles southwest of the park.

Holotype, a male No. 26 in my collection.

The following is a modification of Col. Casey's key (1914) to receive the above species:

Anterior tibiæ unidentate in males.
Polyphylla uteana Tanner.

The only other species in this group is one *P. gracilis* Horn, described from specimens collected in Florida. *Gracilis* is a very different species, being much smaller.

Anterior tibiæ edentate in males.
Polyphylla rufescenta Tanner.

This is a new group and *rufescenta* is an outstanding species; its characters clearly sets it off from all other described species.

Dichelonyx truncata Lec. One specimen taken in May.
Hoplia laticollis Lec. Several specimens taken in May.
Anomala binotata Gyll. One specimen taken in June, 1922.
Spilosota hirta (Lec.). Rare.
Xyloryctes faunus Csy. Several specimens.
Dynastes granti Horn. Several specimens taken at Springdale and Rockville in the spring.
Cremastocheilus armatus Walk. Taken in May under stones.

FAMILY LUCANIDÆ.

Pseudolucanus mazama (Lec). Common in July and August.

FAMILY CERAMBYCIDÆ.

Prionus californicus Mots. Common in August.
Spondylis upiformis Mann. Several specimens taken in May on the Mesa.
Romaleum sp.?
Rhagium lineatum Oliv. Common in the Yellow pines, **Pinus ponderosa.**
Rosalia funebris Mots. Three specimens collected.
Tragidion peninsulare Schffr. Seems to be rare.
Leptacmaeops cubitalis (Lec.). One specimen collected.
Baytle ignicollis (Say). Specimens taken in July.
Moneilema shantzi Csy. Two specimens taken on **Opuntia** sp.?

Monochamus sp.? Doubtful about this species, it may be new.
Leptura chrysocoma Kby. Common on the mesa in July.
Batyleoma suturale (Say). Several specimens taken in May.

FAMILY CHRYSOMELIDÆ.

Saxinis saucia Lec. One specimen taken in July.
Pachybrachys mellitus Bowd. Common in May on **Gutierrezia sorothræ.**
Pachybrachys bivittatus (Say). Taken along with **mellitus.**
Pachybrachys sp.? May be new.
Cryptocephalus sp.? Two specimens taken in May.
Diachus erasus Lec. Specimens taken in June with the net on vegetation.
Graphops nebulosus (Lec.). One specimen collected in May.
Glyptoscelis squamulata Cr. Common in May on **Salix amygdaloides.**
Paria canella var. **quadriguttata** Lec. Common in May on **Gutierrizia sorothræ.**
Chrysochus cobaltinus Lec. Specimens taken in July on **Asclepias galioides.**
Zygogramma conjuncta var. **pallida** Bland. One specimen collected in August on **Helianthus fascicularis.**
Gastroidea cyanea var. **caesia** Rogers. One specimen taken in May.
Lina arizonæ (Cr.). Specimens collected in May.
Monoxia consputa (Lec.). Common on **Salix** sp. in July.
Monoxia puncticollis (Say). Common on Willows.
Diabrotica duodecimpunctata var. **tenella** Lec. Common on many kinds of plant life.
Scelolyperus longulus (Lec.). Specimens taken by sweeping weeds with a net.
Disonycha quinquevittata (Say). Common in May on several species of **Salix.**
Systena mitis (Lec.).
Chalcoides helxines (L.). Common.
Baliosus ruber (Web.). Common in May of 1923 on **Quercus utahensis.**
Microrhopala cyanea (Say). Collected in August on weeds.
Trirhabda canadensis (Kby.). Collected on willows and oaks.

FAMILY MYLABRIDÆ.

Mylabris sp. I have three species of Mylabris that have not been satisfactorily determined.

FAMILY CURCULIONIDÆ.

Rhynchites bicolor var. **cockerelli** Pierce. Specimens taken on **Rosa** sp.
Rhynchites aureus Lec.
Attelabus sp. Several specimens taken on **Robinia neomexicana** A. Grey in May.
Apion proclive Lec. Common on various plants.
Eupagoderes varius (Lec.). Specimens taken on **Covillea tridentata** (DC.) near the entrance to the park.

Thricolopis inornata Horn. Common.
Dorytomus laticollis Lec. Many specimens taken under the dead bark of the cottonwoods, in August.
Anthonomus haematopus var. confusus Dietz. Common in the Yellow Pine.
Acanthoseelis acephalus (Say). Collected on several different species of willows.
Rhodobaenus 13-punctatus (Ill.).

FAMILY SCOLYTIDÆ.

Dendroctonus convexifrons Hopk. Taken at the saw-mill on the east mesa, in May.
Dendroctonus monticolæ Hopk. Taken on east rim of canyon in May.
Dendroctonus ponderosæ Hopk. In Yellow Pine on east rim.
Dendroctonus valens Lec. Common on the east mesa.
Hylastes sp.? Several specimens taken in May.
Pityogenes carinulatus (Lec.). Specimens taken on **Abies concolor.**

LITERATURE.

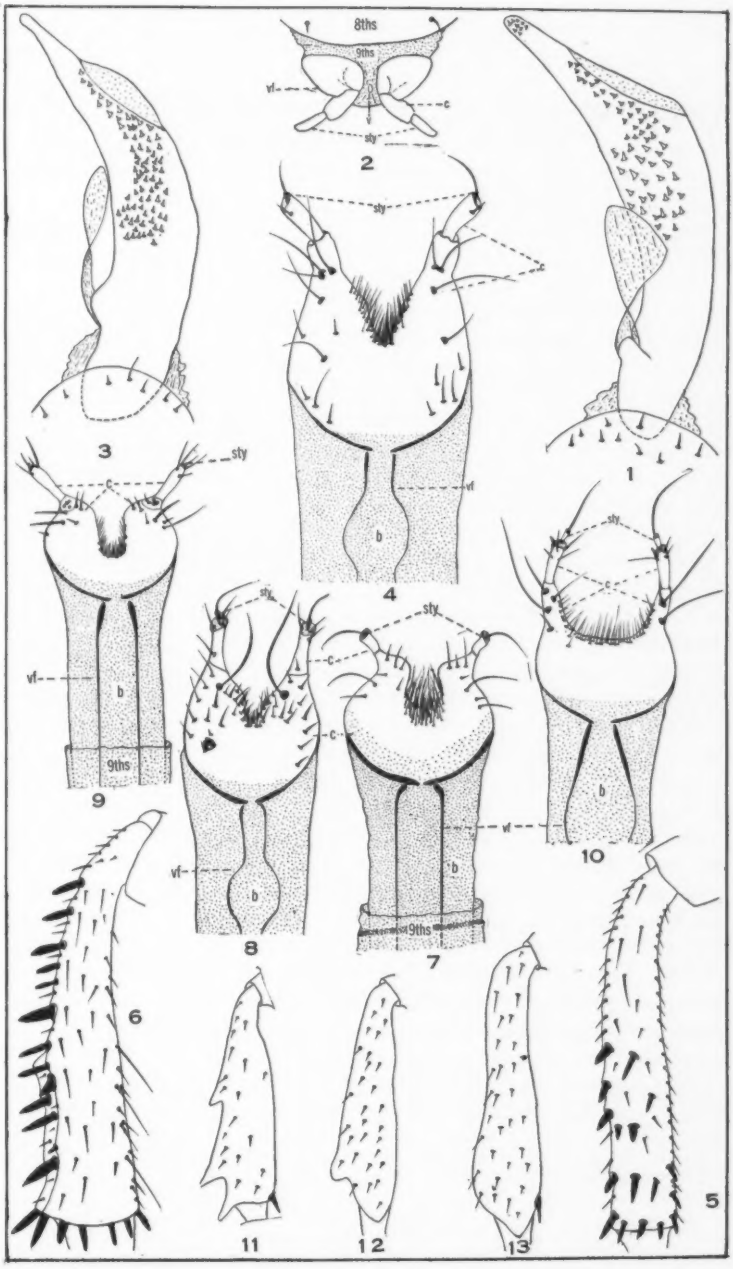
Blaisdell, F. E. 1928. Two new species of Coelocnemis Pan-Pacific Entomologist, Vol. IV, No. 4. pp. 163–65.
Casey, Thos. L. 1895. Coleopterological Notices. Ann. N. Y. Acad. Sci. VI.
1914. Memoirs on the Coleoptera. V.
1920. Memoirs on the Coleoptera. IX.
Fall, H. C. 1917. Two New Varieties of Cicindela tranquebarica From California. Bull. Brooklyn Ento. Soc., Vol. XII, No. 5.
Fall, H. C. 1928. A review of the Genus Polyphylla. Proc. Ent. Soc. Wash., Vol. XXX, No. 2. pp. 30–35.
Leng, C. W. 1920. Catalogue of the Coleoptera of America North of Mexico.

EXPLANATION OF PLATE XIV.

Fig. 1. View of the genitalia, aedeagus, of *Axinopalpus utahensis* Tanner, New Species.
Fig. 2. Ventral view of the female genitalia of *Axinopalpus biplagiatus* Dej.
Fig. 3. View of the genitalia, aedeagus, of *Axinopalpus biplagiatus* Dej.
Fig. 4. Ventral view of the female genitalia of *Trichochrous zionicus* Tanner, New Species.
Fig. 5. Anterior tibia of *Trichochrous zionicus* Tanner, New Species.
Fig. 6. Anterior tibia of *Trichochrous antennatus* Mots.
Fig. 7. Ventral view of the female genitalia of *Trichochrous antennatus* Mots.
Fig. 8. Ventral view of the female genitalia of *Trichochrous laticollis* (Mann.).
Fig. 9. Ventral view of the female genitalia of *Trichochrous nubilatus* Csy.
Fig. 10. Ventral view of the female ganitalia of *Eudasytes hirsutus* Blais.
Fig. 11. Anterior tibia of *Polyphylla diffracta* Csy.
Fig. 12. Anterior tibia of *Polyphylla uteana* Tanner, New Species.
Fig. 13. Anterior tibia of *Polyphylla rufescenta* Tanner, New Species.

ABBREVIATIONS.

Sty.....Stylus
C.....Coxite
Vf.....Valvifer
V.....Vulva
b.....baculum
8ths.....eighth sternite
9ths.....ninth sternite



Vasco M. Tanner

THE EPIPHARYNX OF LAMELLICORN LARVÆ (COLEOP.), WITH A KEY TO COMMON GENERA.*

WM. P. HAYES,
University of Illinois.

INTRODUCTION.

A study of the distinguishing characters of American Lamellicorn larvæ has been a long felt need. Moreover, their economic importance makes such a study of extreme value. A reiteration here of the importance of this group of insects is scarcely warranted, except to point out that because of the diversity of their habits and the various lengths of their life-cycles, it is highly desirous to be able to recognize, at least the different genera and when possible the species belonging to the genera. Forbes (1894, p. 97) in his Eighteenth Report stated that "life-histories are not sufficiently different to make discrimination of species a matter of practical importance and for economic purposes consequently, the white grubs may usually be classed as one." A little later in the same report (footnote, p. 105), in speaking of the verification of life-histories he says "it is necessary that the observer should learn to distinguish species or at least groups of species of these insects in the grub and larval stage." Forbes then pointed out differences between *Ochrosidia* (*Cyclocephala*) and *Phyllophaga* (*Lachnosterna*) grubs. The latter genus was divided into three groups—the *hirticula-rugosa*, *fusca-inversa* and *gibbosa* (now *futilis*) group. Except for the work of Forbes and scattered isolated descriptions, no attempt was made in this country to characterize the various groups of the family until Böving (1921) published a short key dealing with several allied genera of the Green Japanese Beetle (*Popillia japonica* Newm.) which is based in part on Schiodte's (1874) work. This generic key indicated the distinguishing characters of one European and five American genera.

In contrast to the work done in America on this group a number of European papers are available and although dealing

*Contribution No. 119 of the Department of Entomology, University of Illinois, Urbana, Illinois.

with but few genera occurring in this country they are of value in a study of this nature. Chapuis and Candèze (1855, p. 452) noted that the habits and metamorphosis of no group of European beetle larvæ were as well known as the Lamellicorns. The first to attempt a classification of these larvæ was DeHaan (1836) in which both external and internal characters were used to distinguish eight genera. DeHaan made use of the malpighian tubules and the drawings in his work of the alimentary canal are especially good. The next attempt at classification was made by Mulsant (1842) who compiled a key based on external characters alone. The same year (1842) Burmeister published in a large measure the groupings of DeHaan. Erichson (1848) presented a study of the group and used an arrangement of the families, which we now recognize as subfamilies. Erichson's key is also found in the Catalogue of Coleopterous Larvæ by Chapuis and Candèze (1855) who brought together the references to descriptions of larvæ known at that time. Schiodte's classical work on the larvæ of Coleoptera is known to most students of coleopterous larvæ. It appeared in 1874 in several parts, of which part VIII deals with the Lamellicorn larvæ. The drawings in this work are indeed excellent. Three years later Perris (1877) published his well known work *Larves des Coleopteres* which contains the most complete key to genera that we have. He added many new descriptions of lamellicorn larvæ. Up to the time of Chapuis and Candèze no larvæ of the subfamily Rutelinæ were known. Both Schiodte and Perris have added to our knowledge of this group and recently Ritterschaus (1927) has described somewhat completely the morphological details of *Anomala ænea* Geer and *Phyllopertha horticola* L. This work is perhaps the first to give any detailed consideration to the epipharynx of white grubs. More will be said concerning this work later.

The present study is an attempt to show the value of the epipharynx as an aid in the discrimination of the various genera available to the writer. The characters of the epipharynx have been correlated with others and a preliminary generic key is appended to the descriptions of the epipharynx as it occurs in various groups of larvæ. At least one description of the epipharynx from each subfamily available is noted. Where wide differences occur within the same subfamily more

than one species is described. The key although preliminary in nature, and admittedly with faults, should be useful for the more common genera found in North America.

MATERIALS STUDIED.

For a number of years the writer was concerned with the study of life histories of Scarabæidæ and during this time a large number of species of reared larvæ have been made available. The majority of the specimens were reared from eggs laid by adults collected in Kansas. However, the collections of the Illinois Natural History Survey have been used freely through the courtesy of Dr. T. H. Frison and quite recently the collections of Prof. J. J. Davis, now the property of the U. S. National Museum, have been received for study through the courtesy of Professor Davis, Dr. Adam G. Böving and Mr. S. A. Rohwer. The latter collection consists mainly of a large number of reared species of *Phyllophaga* but three or four other genera not in the writer's collections were thus made available for study. The drawings were made by one of my students, Mr. Carl Mohr, through the aid of a grant from the Graduate School of the University of Illinois.

The descriptions of the epipharynx which follow are in most instances made from reared specimens concerning whose identification there is no doubt while with a few species which are readily recognizable by their habitus, habitats or habits, there is reasonable surety of their correct identification.

THE EPIPHARYNX.

The epipharynx although an internal structure is one that is easily accessible and can be examined without injury to the specimen by merely inserting a needle under the labrum and raising it up. It can also be studied in living larvæ without any apparent harm being done to the individual. The characters of the epipharynx have not been given detailed consideration by previous workers. Schiodte (l. c.) figured the epipharynx of *Geotrupes* and his drawing (Fig. 32) of this genus is here copied. Böving (l. c.) has figured and briefly described the epipharynx of *Popillia japonica* Newm. Neither of these writers have attempted to name the various parts. A recent German worker (Rittershaus, 1927) has described in some detail the epipharynx of *Anomala ænea* Geer. and *Phyllopertha horticola* L. She is the first to assign names to some of the various parts. Her terms will be mentioned later.

The epipharynx (Figs. 1-44) is defined as the ental wall of the labrum. Its proximal extent is limited by the tormæ which are situated at the

lateral extremes of the clypeo-labral suture. However, a few of the setæ and an important sensory area, located between the mesal ends of the tormæ, are proximad of this suture and are thus on the ental surface of the clypeus.

The *tormæ* (t.) are heavily chitinized structures on the ends of the *clypeo-labral suture* (cl. st.) which extend toward the mesal-line and in some larvæ of this group meet and fuse on the mesal line. In many insects they serve as a landmark in determining the extent of the clypeus and labrum when the clypeo-labral suture is indistinct or absent. In the present group of larvæ the tormæ exhibit various sizes and shapes and further study may find them of more taxonomic importance. They were found useful in the separation of *Canthon* and *Onthophagus*. The *lateral lobes* (l. l.) and *median lobes* (m. l.), as here considered, apply to the lateral and distal margins of the labrum of those species in which the margin is conspicuously biemarginate. The *lateral striæ* (l. s.) occurring in Melolonthinæ, and a few other forms are short, tranverse carinæ at the bases of setæ of the lateral margin. In *Phyllophaga* a second group of carinæ more distal and somewhat removed from the margin are called *submarginal striæ* (sm. s.). On the median line and somewhat removed from the distal margin is an important area containing various sensillia and strong chitinous spines. This area is here called the *distal sensory area* (d. s. a.). The structures in this region which are in most cases, obviously strong spines were called by Rittershaus (1927) "chitinous pegs," and the area upon which they are situated, and upon which are also found numerous pore-like sensillia, was called a "*chitinous plate.*" The *chitinous pegs* are here called *spines* (sp) and the *chitinous plate* is the *distal sensory area.* The *sensillia* (sa). are located at the bases of the spines, being between them and the distal margin.

The *proximal sensory area* (p. s. a.) is the region between the ends of the tormæ and in many species proximad of the *clypeo-labral suture* (cl. st.). This region contains a strong, rounded tubercle called by Rittershaus the *sense-cone* (s. c.). High magnification shows it to contain about four sensillia (Fig. 45). One of these sense-cones is described in detail in the description of the epipharynx of *Phyllophaga futilis.* On the right side of the *sense-cone* (left in drawings) is a variously shaped *chitinous plate,* (c. p.) which is not present in some species. On the left side of the *sense-cone* is a non-setose area which in some forms (*Phyllophaga*) contains 20 to 25 pore-like sensillia. In other species two or three sensillia are found in this area and in still others none occur. To distinguish these they may be called the *clypeal sensillia* (cl. s.) since they are usually on the clypeus. The remaining surface of the epipharynx is covered with variously arranged articulate *setæ* (st.) which are usually so arranged as to leave a clear, non-setose area in the center of the epipharynx. Frequently, there are found, interspersed among these setæ, numerous groups of more delicate, non-articulate spines, especially occurring in the region of the *clypeo-labral suture.*

SCARABÆIDÆ.

COPRINÆ, TRIBE SCARABÆINI.

Canthon lævis (Drury).

The epipharynx (Fig. 31) is symmetrical and rather strongly trilobed. The median lobe on the distal margin is strongly developed and is rather densely covered with strong, hooked setæ. The lobe is continued on the ental surface into a prominent rounded process which bears six, shorter setæ. There is a central pair of setæ arranged tranversely, and laterad of these on each side is another pair arranged longitudinally. Still farther laterad of these setæ are two pit-like structures which somewhat resemble the alveolus from which setæ have been removed but which are more probably sensoria. The lateral lobes are rather densely covered with long, slender, curved setæ. Mesad of these on the ental aspect is located a group of not over a dozen more robust but shorter setæ which are recumbent and their apices are directed mesad. These are apparently unequal in number on each side with a few more present on the right than on the left side. Behind, or proximad, of the median lobe in cleared specimens, is a dark, tranversely, oval structure which probably would not be apparent in fresh specimens. Near the clypeo-labral suture a few slender setæ are grouped on each side which are recumbent and their points are directed meso-proximad. The tormæ are not as well developed as in some other scarabæid larvæ. They appear strongly curved on the sides and each extends on its mesal end transversely across the epipharynx to meet and fuse with the torma of the other side.

COPRINÆ, TRIBE COPRINI.

Copris tullius Oliv. (anaglypticus Say).

This species (Fig. 34) also has the labrum symmetrical, strongly trilobed and biemarginate. The description which follows is made from a single specimen whose details are difficult to make out. Its median lobe bears four long setæ hooked at the tips and also some shorter setæ. The lateral lobes have only a few short setæ. No distinct distal sensory area can be distinguished and there is apparently a group of short setæ arranged in the form of a circle. Near the clypeo-labral suture a darker area may be the sense cone of the proximal sensory area. Other than the circle of setæ only a few short scattered setæ are apparent on the ental surface of the lateral lobes. The tormæ appear branched. One of the branches being long and extending far onto the clypeus.

The epipharynx of *Onthophagus* (*pennsylvanicus* Har.?) (Fig. 35) belonging to this tribe shows quite a different arrangement of the tormæ and a somewhat similar circular group of setæ in the central area. The distal margin is provided with intermixed long and short strongly hooked setæ.

APHODINÆ, TRIBE APHODINI.

Aphodius sp.

The species (Fig. 36) considered was taken in large numbers from manure. Not having been reared the specific identity is uncertain but from the large size of the grubs it is probably *Aphodius fimetarius* (L.) which is one of our largest and most common species. The epipharynx bears comparatively few setæ both on the margin and on its inner surface. The margins are smooth proximally but rather irregular distally where they are produced into a broad, single lobe. The widest area is about in the middle where a single articulate setæ is situated with another slightly disto-mesad. Between the broadest point of the lateral margins and the distal lobe six setæ, two long and four short are found on each side. The distal lobe bears two long and four short setæ on the margin and about four short setæ remote from the margin. Behind the median lobe on each side are two irregularly, triangular chitinized areas. Between these and immediately distad of a prominent circle of short chitinous processes or spines are two sense-cones. The circle of chitinous processes or spines at first glance resemble setæ but they are blunt at their tips, non-articulated and at the base of some of the distal spines is an indication of a sensory pore. This circle extends to the clypeo-labral suture. The tormæ meet and fuse on the middle line from where a chitinous process extends distad to the center of the circle of spines at which place it expands slightly on the end. On the clypeus are two small chitinous plates found near the fused tormæ.

GEOTRUPINÆ, TRIBE GEOTRUPINI.

Geotrupes stercorarius L.

No specimens of this genus were available. The drawing (Fig. 32) is a copy of Schiodte's drawing. In general it is somewhat similar in shape to *Canthon lævis*, being symmetrical and trilobed. The inner aspect has comparatively few setæ. The median lobe is strongly produced on the inner aspect. Its margin shows eight strong setæ while eight others apparently recumbent and directed proximad are found just within the margin on the inner aspect. A strongly curved, transverse darker area is proximad of these spines and two series of small setæ are proximad of this darker area. The two series are semicircular in arrangement. The median lobe is produced into a blunt, rounded process which crosses the clypeo-labral suture. The surface of the lateral lobes bear setæ that are shorter and stouter than those of the lateral margins. They are, as in *Canthon*, unequal on each side with a few more present on the right side than on the left. They are recumbent and their apices are directed mostly toward the meson. The tormæ are not shown in Schiodte's drawing.

GLAPHYRINÆ

Amphicoma sp.

The epipharynx of this genus (Fig. 33) is described from specimens in the Davis collection from Hadley, Mass., collected May 29, 1916 by H. E. Smith. Unlike most of the Laparosticti the labrum is not strongly trilobed and only faintly biemarginate. The margins, both distal and lateral, are interspersed with long and short setæ. The long ones being several times longer than the short setæ. The median lobe bears the distal area which is almost on the margin. This area contains about twelve sensillia in the form of small rounded pores. They seem to be set off from the rest of the epipharynx by a darker, chitinous semi-circular band which bears a few setæ. The remaining surface of the epipharynx is covered with rather densely placed setæ arranged in a circle with larger stronger setæ on the distal rim of the circle. In the cleared circle and proximad of the larger setæ are a few, small rounded areas that may be sensillia or trichopores. The right torma is extremely long, reaching far beyond the median line. The left torma is much shorter. The proximal sensory area is behind the right torma in the area formed by a strong curve of the torma. It is composed of a strong tubercle-like sense-cone, to the right of which are two smaller cones. A few minute spines of varying sizes are to be seen proximad of the right torma and two or three pore-like sensillia are mesad of the sense-cone.

MELOLONTHINÆ, TRIBE SERICINI.

Serica sp.

This species (Fig. 3) is described from specimens in the Illinois Natural History Survey collection determined as *Serica sp.* by Dr. A. G. Böving. They agree closely with the description of *Triodonta* (*Serica*) *aquila* Cast. by Perris (p. 116). The labrum is more symmetrical than most of the Melolonthinæ with the distal lobe rather strongly produced. The lateral lobes are margined on the inner aspect by the series of lateral striæ. The margins of all three lobe are provided with rather numerous setæ which increase in length distally. There are three prominent spines in the distal sensory area but no sensillia have been found. Close study may probably show that they are present. The surface of the epipharynx is covered with small setæ leaving a cleared central space. The tormæ are unequal in size and dissimilar in shape. The right torma reaches to near the median line and at its end is located a conspicuous sense-cone of the proximal sensory area.

MELOLONTHINÆ, TRIBE MELOLONTHINI.

Diplotaxis sp.

Described from a first instar larva (Fig. 4). The general form is broadly oval, with only the distal end bearing about eight setæ. The

lateral margins are slightly rugose but lack setæ. Distally the ental surface bears a small patch of comparatively long setæ which are directed meso-distad. They meet on the meson and overlap each other. Between these and the distal margin are a few short, broad setæ. The lateral margins lack the series of lateral striæ which occur in other Melolonthinæ and also in the tribe Anomalini. The distal sensory area is located at the bases of four spines whose apices are directed proximad. Five sensillia can be distinguished at the base of these spines. An irregular series of short setæ extends from these spines to the clypeal area. The tormæ are poorly developed. The left one being more heavily chitinized than the right which is almost obsolete. In the area of the epipharynx distad of the right torma is a darkened, narrowly chitinized area, which extends disto-proximad. This may not be a structure that is normally present. A small, dark area distad of the left torma is probably a sense-cone of the proximal sensory area.

MELOLONTHINÆ, TRIBE MELOLONTHINI.

Phyllophaga futilis Lec.

The labrum (Fig. 5) is asymmetrical and the distal margin is extended to form a lobe which is covered with a mass of long, slender articulate setæ. The lateral margins are rounded and bear on each side about 16 broad and rather strongly curved, articulate setæ. Near the base of each of these setæ on the ental aspect is a narrow ridge or carina extending toward the meson. This series of carina give each margin a file-like aspect. They are the lateral striæ. Immediately behind the distal lobe and slightly laterad of the meson is another series of ridges, about nine in number. The individual ridges extend nearly disto-caudad while the series taken as a whole lies obliquely. These are the submarginal striæ. Immediately mesad of the submarginal striæ on the right (left in sketches) is a darkened, more heavily chitinized area, the distal sensory area. Near the meson and slightly in front of the middle is a group of six strong spines pointing proximally and having their bases arranged in almost a semi-circle. Three or four other spines of the same nature are situated caudad of the semi-circular group of six. These spines are distinguishable from the neighboring setæ by their larger size and the fact that they are not articulate at the base. Distad of the spines and located near their bases is a group of pore-like sense-cones arranged somewhat semi-circularly but irregular as to their distance apart. There are six comparatively large cones between which are five smaller ones.

Proximad of the series of spines and sense-cones in the distal sensory area is a large number of articulate recumbent setæ whose apices are directed mesad and meso-caudad. They likewise are semi-circularly arranged leaving an area in the center with no setæ. The series extends to the tormæ on the proximal margin of the labrum. On the left of the clear, central area (right in sketch) near the proximal margin is a cluster of long, slender, fixed spines. These lie in part between the branched arms of the left torma.

The tormæ, located on the clypeo-labral suture are long and irregular. They are asymmetrical. The right torma extends almost to the meson and is unbranched. The left torma is shorter and is two-branched near its mesal end with one of the branches, long and slender, extending far onto the labrum. At the mesal end of the left torma is another clump of fixed, slender spines and mesad of these are about 25 clypeal sensillia. Between these sensillia and the end of the right torma slightly off the median line is a triangular chitinized area almost spine-like, called the *chitinous plate* by Ritterschaus. It is directed meso-distad. Immediately mesad of the chitinous plate and apparently partly underlying it is a broader, less heavily chitinous area pointing in the same direction. It is covered with long, slender spines (Fig. 45). In cleared specimens, four sense-cones are apparent which are intermediate between the *sensillium ampullaceum* and *sensillium coeloconium* types. These consist of a sunken fungiform cone which connects with a long, somewhat bottle-shape canal. The central structure containing the sense-cone is called the "sense-cone" by Ritterschaus. The chitinous plate and the area bearing the sense-cones is located on the ental surface of the clypeus called by some writers (MacGillivray, et al.) the *epigusta*. Just behind the sensory area is a long, tranverse, strongly bowed, chitinous bar. All of the structures between the tormæ comprise the proximal sensory area.

The epipharynx of *Phyllophaga lanceolata* (Say) (Fig. 6) differs in some detail from the common epipharyngeal type found in this genus. The most conspicuous differences being a more nearly symmetrical outline of the labrum and the presence of only four prominent spines in the distal sensory area. A closely allied species, *P. cribrosa* (Fig. 9) is of the typical form including the usual number of spines of the distal sensory area. Another species *P. tristis*, (Fig. 11) differs in having but three prominent spines in the distal sensory area.

In the genus *Polyphylla* (Fig. 1) belonging to the tribe Melolonthini the characters are quite similar to those of *Phyllophaga* except for a somewhat different arrangement of the spines in the distal sensory area. The lateral striæ are also shorter and less distinct.

MELOLONTHINÆ, TRIBE MACRODACTYLINI.

Macrodactylus subspinosus (Fab.).

The epipharynx of this species (Fig. 2) is described from specimens in the Davis collection of the U. S. National Museum. The labrum is asymmetrical with a single emargination of the distal margin slightly to the right of the median line. The margins, both lateral and distal, are provided with intermixed long and short setæ. Lateral striæ are present on the inner surface of the lateral margins. Beginning at the notch or distal emargination is a more darkly, chitinized, irregular plate, which extends proximad to the distal sensory area. In this area is a group of pore-like sensillia arranged in an irregular semicircle. Some of the sensillia are arranged in pairs. From this same area four strong spines are directed toward the clypeo-labral suture. Between the

distal sensory area and the clypeo-labral suture a number of setæ are arranged in a circle with a non-setose area in the center. The tormæ are unequal in size. The right torma is considerably smaller than the left. At the end of the right torma is a prominent row of slender, elongate spines. The right torma extends to near the median line where the sense-cone of the proximal sensory area is located. In some specimens the cone is a single tooth-like structure, while in others it appears as two teeth as shown in figure 2.

RUTELINÆ, TRIBE ANOMALINI.

Popillia japonica Newm.

The epipharynx in the tribe Anomalini is quite similar in all the species studied. It shows a close relationship to the Melolonthinæ in the presence of the lateral striæ which occur only in these two groups. There is also some resemblance in the form and arrangement of the sensory areas including the spines which, however, are fewer in number than in the Melolonthinæ. The following species were available for study. *Popillia japonica* (Fig. 21), *Strigoderma arboricola* (Fig. 20), *Anomala orientalis* (Fig. 16), *A. kansana* (Fig. 17), *A. binotata* (Fig. 19) and *A. innuba* (Fig. 18). Except for some variation in the number and arrangement of the spines of the various species they exhibit rather marked uniformity in structure. The same can be said of *Anomala phyllopertha* which has recently been described by Ritterschaus (1927). The epipharynx of *Popillia japonica* has been selected for description.

Böving (1921) has figured the epipharynx of *Popillia japonica* but has not given a detailed description of its structure. The labrum (Fig. 21) is strongly asymmetrical as is the case with the others studied in this tribe, except *Anomala orientalis* which is nearly symmetrical. The distal margin is usually produced into an acute lobe covered with rather long setæ. The lateral margins are strongly rounded and bordered with short, curved setæ at the bases of which are to be found the lateral striæ. Intermixed with the short setæ are a few extremely long setæ. The distal sensory area has three strong spines and two large, articulate setæ which might be confused with the fixed spines. At the bases of the fixed spines are about eight sensillia arranged in a curved line. Between the distal sensory area and the clypeo-labral suture numerous smaller setæ are circularly arranged with the customary, smooth, non-setaceous, central area. The tormæ are of nearly equal size and do not reach the median line. At the mesal end of the right torma a pointed, chitinous plate and a tubercle-like sense-cone comprises the proximal sensory area. Two pore-like clypeal sensillia are to be found in the cleared area mesad of the sense-cone and slightly proximad of the distal end of the left torma. Latero-proximad of these pores are a number of minute spinules only noticeable under high magnification.

RUTELINÆ, TRIBE RUTELINI.

Cotalpa lanigera (Linn.).

Three species of this tribe were studied. They differ strikingly from the tribe Anomalini of the same subfamily and exhibit affinities

toward the Dynastinæ. *Polymæchus brevipes* Lec. (Fig. 23) is decidedly irregular in outline. *Pelidnota punctata* (Linn.) (Fig. 22) is more regular and is wider than long while *Cotalpa lanigera* (Linn.) (Fig. 24) is longer than wide. The arrangement of the distal sensory area is sometimes hard to make out. It varies more markedly than in the Rutelini.

In *Cotalpa* the general form is only slightly asymmetrical, the sides are gradually rounded and no prominent lobes or emarginations are formed. The lateral margins are covered with curved setæ which are comparatively short in the proximal region becoming longer distally. No lateral striæ are present. The distal sensory area is composed of a single chitinous structure produced into a point resembling a spine. Proximad of this structure are a number of strong, spine-like, articulated setæ. They are directed toward the clypeus while the remaining setæ covering the epipharynx are directed toward the meson with a smooth area in the middle. The tormæ are irregular, the left one being curved distad while the right lies tranversely. A fold in the integument at the mesal end of the left torma makes this torma appear much longer than it is. At the end of the right torma is the proximal sensory area composed of a minute triangular, chitinous plate and a broadly rounded sense-cone.

DYNASTINÆ, TRIBE CYCLOCEPHALINI.

Ochrosidia immaculata (Oliv.).

This species (Fig. 25) is characterized by the absence of lateral striæ along the ental surface of the lateral margins and by the presence of two broad chitinous spines in the distal sensory area. The right spine is nearly twice as broad as the left and its apex is more rounded. In cleared specimens three sense-cones can be distinguished in this spine. The left spine is more pointed and has at least one sense-cone in it. The lateral margins of the labium are comparatively smooth and strongly rounded. They bear about 14 broad and strongly curved setæ which point distally, each of which gradually becomes longer in length. The distal margin is more rugose and is armed with a group of long setæ. Between this group of setæ and the spines described above is a small, narrow, somewhat curved, chitinous plate or ridge which lies obliquely. There are two sense-cones located in the space between this chitinous structure and the two broad spines. A large series of various sized setæ lie between the spines and the clypeo-labral suture. The setæ are inclined in all directions and are so arranged as to produce a non-setaceous cleared area in their center.

The tormæ are comparatively short and decidedly asymmetrical. The torma on the left is at first directed proximad but it soon makes a prominent bend and narrows down towards its extremity to end near the clypeo-labral suture. The right torma is at first curved proximad but has a less conspicuous curve so that it extends in an almost transverse direction. At its distal end in the proximal sensory area on the clypeus are two chitinous processes pointing distally. The one almost abutting the end of the torma and slightly overlapping it, is the larger.

This is the chitinous plate. No sensillia were noted in it but the smaller process which is the sense-cone shows one sensillium. Scattered throughout the large central group of setæ are a number of very small dots which are circular in outline and exhibit within them another concentric circle. These are doubtless pore-like sensillia.

Representatives of three other of the five North American tribes of this subfamily have been studied—*Ligyrodes relictus* (Say) (Fig. 26) and *Ligyrus gibbosus* DeGeer (Fig. 27) of the Pentodontini, *Strategus antæus* (Fab.) (Fig. 28) of the *Oryctini and Dynastes tityrus* (Linn.) (Fig. 30) of the Dynastini. They differ from *Ochrosidia immaculata* principally in that the chitinous portion of the distal sensory area is produced into a single point, except in *Dynastes* which has two projections located much closer to the margin and much larger proportionally than in *Ochrosidia*.

CETONIINÆ, TRIBE GYMNETINI.

Cotinis nitida (Linn.).

The Cetonniinæ are characterized by having the labrum symmetrical and usually biemarginate and trilobed. The distal sensory area is composed of a strongly curved group of comparatively short setæ or spines which are stouter than the remaining setæ. In a few species (*Osmoderma et al.*) these setæ are apparently not articulate and, as such, are considered as spines.

In *Cotinis nitida* (Fig. 37) the labrum is deeply biemarginate on its ectal surface but not strongly so on the ental aspect. The trilobed condition is therefore not strongly marked when viewing the epipharynx. The lateral lobes have a few short setæ becoming more numerous and longer distally. The median lobe has only a few long setæ. It is marked off internally on its lateral areas by a darkly chitinized band extending on each side from the margin to the distal sensory area. Between these bands and at the base of the circular row of setæ are two pore-like sensillia. The circular row is composed of about 15 setæ and proximad of these are a number of similar sized setæ. The remaining surface of the epipharynx is covered with longer and more slender setæ which become shorter laterally. There is left on the central disk a comparatively small area devoid of setæ. The tormæ are shorter than in most groups, with the right somewhat longer than the left one, Between them in the distal sensory area is a single, large sense-cone. The chitinous plate of this area is absent. Some distance proximad of this sense-cone are two pore-like clypeal sensillia.

Among the other species studied in this subfamily, *Trichiotinus piger* (Fab.) (Fig. 44) differs more radically than do others of the group. It was studied in a first instar larva. It does not show the trilobed feature nor is the circular row of setæ in the distal sensory area as marked. *Cremastocheilus sp.* (Fig. 39) was studied from a moult skin in which the epipharynx is nearly devoid of setæ that are apparently rubbed off since numerous trichopores are present having the characteristic arrangement of the group. A single sense-cone is present in the proximal sensory-area. Three species of *Euphoria* (Figs. 41, 42 and 43) are

markedly similar while *Stephanucha pilipennis* Kr. (Fig. 40) appears to lack the sense-cone of the proximal sensory area and has the setæ of the distal sensory area more obliquely curved.

TROGIDÆ.

Trox sp.

This subfamily of Scarabæidæ has recently been raised to family rank. Tillyard has pointed out in his new book, "Insects of Australia and New Zealand" that the Trogidæ are intermediate between the Scarabæidæ and Lucanidæ. This is also apparent in the larvæ in the condition of the stridulating apparatus of the meso- and metathoracic legs and the feeble trilobed anal area, which suggest relationships to the Lucanidæ.

The epipharynx of *Trox sp.* (Fig. 15) is symmetrical and not trilobed nor emarginate. Its lateral margins are almost devoid of setæ except distally where five or six large setæ are continuous with those of the distal margin. The median, distal margin is produced into four conspicuous tubercles each of which bears a strong seta. The distal sensory area is indistinct and in the specimens examined its detail is hard to distinguish. Only a few setæ are scattered over the lateral lobes, about four on each lobe. The central area is darkened in the specimens and no detail can be made out. The tormæ are small, the right one being the larger. No detail of, or evidence of, a proximal sensory area is apparent.

LUCANIDÆ.

DORCINÆ.

Dorcus sp.

This genus (Fig. 12) is represented by some larvæ in the University of Illinois collection labeled *Dorcus sp.* with no other data. From its similarity, and yet different habitus of the epipharynx, to that of *Sinodendron* the determination is probably correct. It lacks the prominent circle of spines found in *Sinodendron*. It is more setaceous both on its distal margin and its ental surface. The distal lobes are not so strongly evident. The emarginations being not so marked. The distal margin is densely setaceous while the lateral margins are nearly bare of setæ. The general shape of the labrum is much like *Sinodendron* being somewhat subquadrate. The entire ental surface is sparsely set with short setæ interspersed with small pores which may be sensillia but also might be the trichopore or alveolus of setæ which have been broken off. No circular area of spines is present but near the middle of one specimen is a semicircular depression which does not appear to be a normal structure. The tormæ are strongly curved at the lateral margin. They extend transversely mesad to unite on the middle line where another chitinous process projects distad along the mesal line a little more than one-third the distance of the labrum.

Behind the fused tormæ is a long narrow sense-cone which is somewhat rounded distally and which ends caudally in three parts. Three small cleared areas near its distal end may be sensillia. On the left side of this structure is a much smaller, more transparent chitinous plate whose distal end is rounded. On the right side of the sense-cone is a much larger backward pointing chitinous plate which ends in a sharp point. No trace of sense-cones is evident in these lateral processes.

ASESALINÆ.

Sinodendron rugosum Mann.

The general shape of the labrum (Fig. 13) is subquadrate with the lateral margins smooth, non-setose and slightly diverging toward the distal end where they round off to form the distal margin which is slightly three-lobed, the lobing being produced by two emarginations, one on each side of the meson. The central lobe bears four setæ on its margin and two others that are submarginal. Each of these setæ arise from a small papilla. On the ental surface the median lobe is rather strongly convex. On the left of the meson behind the setæ is a slight, chitinous spine which is frequently hard to find. Overlapping the median lobe and extending to the clypeo-labral suture is a prominent, almost circular row of spines enclosing a slightly depressed, smooth area. The lateral lobes of the distal margin bear five or six setæ, in one specimen five, on the right lobe and six on the left lobe. The rest of the epipharynx is smooth. The tormæ are stout on the lateral margins. A pointed process extends meso-distally while another transverse process meets a similar one from the other side to fuse mesally where a pointed projection extends distally along the meson into the clear area surrounded by the circle of spines. On the clypeus, proximad of the central, chitinized process of the tormæ are two chitinized plates somewhat setaceous on their distal ends and between these is a long tooth-like process. No sensillia, as found in *Phyllophaga* can be made out in these processes even with the oil immersion lens. The setaceous, distal ends of the lateral plates are probably sensory while the central process shows under high power a clear central area that may be thinner and serving in a sensory capacity.

PASSALIDÆ.

Passalus cornutus Fab.

The epipharynx (Fig. 14) of *Passalus cornutus* is nearly symmetrical and trilobed. The lateral lobes are clothed with a mixture of long and short setæ while the median lobe has seven setæ on its margin. The median lobe on the ental aspect is bare of setæ to near the middle of the epipharynx where a series of short setæ are arranged in two rather well defined curved rows. The setæ in these rows have their apices directed distally which is the opposite condition in the epipharynx of other species studied. Laterad of these middle rows of setæ are a number of longer setæ with their tips directed mesally. No sensillia have

been found but closer study of the distal margin of the median lobe may reveal their presence. The tormæ are unequal in size, the left being the larger. They are comparatively small. The present description is made from the specimen from which figure 14 was made. Other specimens show the setæ of the median area to be arranged somewhat differently.

MISCELLANEOUS DEFINITIONS

In order to use the appended key to genera it is probably necessary to explain a few of the terms found in it. The *radula* is the rake made up of the spinose and setose area located on the ventral aspect of the last abdominal segment. The function of this structure was described by the writer (1927) as serving as a rake to clean the mouthparts. Ritterschaus (l.c.), in her paper, appearing a short while later, suggests the same function. The *radula* may or may not possess a median, longitudinal, double row of non-articulating spines, usually recumbent, and with their apices directed toward the median line. Frequent use of the presence or absence of this character is made in the key. The setæ of the *radula* are articulate and may or may not be hooked at their tips.

The *stridulating organs* of the mouthparts consists of a series of transverse striæ on the caudal aspect of the mandibles. The striæ are usually (except in *Phyllophaga*) arranged in the form of an oval. On the cephalic aspect of the maxillae is a series of variously shaped spines or teeth which work in apposition to the striæ of the mandibles. The shape and arrangement of these spines proved the only satisfactory character in the separation of the subfamily Dynastinæ from the tribe Rutelini of the subfamily Rutelinæ.

The *spiracles* of the larger groups are important characters. They have only been used here in their grosser aspects. Some writers have made use of the minute openings or pores in the peritreme but these are usually hard to distinguish.

The so-called *sac* is a term which is used by some European workers to designate the region of the abdomen behind the last spiracular-bearing segment. The sac on its dorsal surface is usually divided by a transversely impressed line which gives in many groups the appearance of two body segments behind the last spiracular-bearing segment. The Cetoniinæ lack this transverse impression and appear as having but a single segment behind the segment which bears the posterior spiracle.

The *maxillæ* may or may not have a distinct galea and lacinia. When they are not distinct and only a single lobe is present the structure is called the *mala*. Imms (Textbook of Entomology p. 17) states that the *mala* is probably homologous with the galea, the lacinia being absent. From certain evidence of which space does not permit an account, and the bifid condition of the maxilla in the Laparosticti it is more probable that the *mala* is a fusion of the galea and lacinia.

The number of antennal segments is sometimes a matter of doubt because the proximal segment is frequently fused to the head and not articulate. In this study, this non-articulate segment is considered the first antennal segment and not as a palpiger as it was interpreted by Schiodte.

LARVAL KEY TO FAMILIES OF SUPERFAMILY SCARABÆOIDEA.

1. Posterior pair of legs small, undeveloped; coxæ modified into a scraping, stridulating apparatus; antennæ three-segmented; body segments not distinctly divided into annulets and nearly devoid of spines and setæ, PASSALIDÆ, genus PASSALUS
   Posterior pair of legs normally developed; legs may or may not be used for stridulation; antennæ four or five-segmented; body segments usually distinctly divided into annulets and more or less covered with spines and setæ 2
2. Anal segment not trilobed on caudal aspect, legs not modified for stridulation except in *Geotrupes* ..... SCARABÆIDÆ
   Anal segment trilobed on caudal aspect; meso- and metathoracic legs modified for stridulation 3
3. Labrum usually biemarginate on its distal margin, trilobed; emargination of peritreme of anterior spiracles on caudal margin as is the case with the remaining spiracles; anal segment strongly trilobed; larvæ feed in wood ..... LUCANIDÆ
   Labrum not biemarginate on its distal margin, more rounded, not trilobed on distal margin; spiracular peritreme of all segments small, open on dorsal margin, poorly defined; anal segment feebly trilobed; larvæ feed in carrion ..... TROGIDÆ, genus TROX

LARVAL KEY TO THE SUBFAMILIES OF SCARABÆIDÆ.

1. Galea and lacinia of maxilla not fused, that is, the mala is deeply bifid; usually copraphagous larvæ ..... LAPAROSTICTI. 2
   Galea and lacinia of maxilla fused to form the mala; mostly "leaf chafers." PLEUROSTICTI. 6
2. Tarsi without claws, (a distal seta may be present); abdomen strongly "humped" on the dorsum; labrum trilobed and biemarginate 3
   Tarsi with claws or the tarsus is bilobed on its distal end, abdomen not "humped" on the dorsum 5
3. Antenna four-segmented ..... COPRINÆ, COPRIS
   Antenna five-segmented 4
4. Tarsus strongly rounded or blunt on its distal end; tormæ of labrum not meeting on the median line; ental setæ of lateral lobes of the epipharynx numerous (more than eight) ..... COPRINÆ, CANTHON
   Tarsus terminating in a long seta; tormæ of labrum meeting on the median line, ental setæ of lateral lobes of the epipharynx scarce (usually one on each lobe) ..... COPRINÆ, ONTHAPHAGUS

5. Tarsus without claws, bilobed on its distal end; posterior pair of legs considerably shortened (not as much so as in Passalidæ); second and third pairs of legs modified for stridulation.....GEOTRUPINÆ, GEOTRUPES
Tarsus with claws which are longer than tarsus; legs not modified for stridulation; third pair of legs not noticeably shortened; body densely setaceous; anal slit transverse.....GLAPHYRINÆ, AMPHICOMA

6. Mandibles on their caudal aspect without an oval, stridulating area made up of transverse striæ; radula usually with two longitudinal rows of mesad pointing spines (not present in *Serica*); anal slit in the form of an obtuse angle.....MELOLONTHINÆ
Mandibles on their caudal aspect, with a distinct oval, stridulating area made up of transverse striæ; with or without two longitudinal rows of mesad pointing spines on radula; anal slit not angulate, and more transverse..... 7

7. Labrum symmetrical (*Stephanucha* is not symmetrical, but it is a rare species), usually trilobed (except in *Trichiotinus*, which is usually recognized by the presence of ocelli); epipharynx with a conspicuous, curved row of small spines in the region of the distal sensory area; dorsum of abdomen behind the last spiracle-bearing segment not divided transversely by an impressed line, thus appearing as one segment; some species are "Back crawlers," others found in soil, wood, and manure.....CETONIINÆ
Labrum asymmetrical, not trilobed; epipharynx without a conspicuous, curved row of small spines in the region of the distal sensory area; dorsum of abdomen behind the last spiracle-bearing segment divided transversely by an impressed line, making it appear as two segments; species of varied habits..... 8

8. Ental aspect of the labrum with a series of transverse striæ on the lateral margins at bases of lateral setæ.....Tribe *Anomalini* RUTELINÆ
Ental aspect of the labrum without a series of transverse striæ on the lateral margins at bases of lateral setæ..... 9

9. Stridulating teeth of maxillæ sharply pointed and curved, apices directed distally; distal segment of maxillary palpus usually without a distinct, setaceous sensory area.....Tribe *Rutelini* RUTELINÆ
Stridulating teeth of maxilla not pointed but strongly truncate being as broad as long, not curved, and not directed distally; distal tooth of the series of stridulating maxillary teeth twice as wide as the others in the series; distal segment of the maxillary palpus usually ending in a setaceous sensory area.....DYNASTINÆ

LARVAL KEY TO GENERA OF SUBFAMILY MELOLONTHINÆ.

1. Anal slit obtusely angulate, not trilobed; tarsal claws of posterior legs less than half as long as claws of the other legs; distal sensory area of epipharynx usually with seven to eight strong spines. A few species of *Phyllophaga* (e. g., *lanceolata* et al.) have less than seven spines, but can readily be distinguished by the lateral striæ of the epipharynx..... 2
Anal slit acutely angulate, faintly trilobed; tarsal claws of posterior legs more nearly equal in length to the claws of the other legs, rarely less than half as long; distal sensory area of epipharynx never with more than four strong spines..... 3

2. Longitudinal double row of spines of radula short, scarcely more than eight spines to a row; head dark brown in color; dorsum of abdominal segments very densely spinose; striations of lateral margins of epipharynx indistinct; epipharynx never with a submarginal, distal row of striæ.....*Polyphylla*
Longitudinal double row of spines of radula longer, usually more than ten spines to a row; head light yellow in color; dorsum of abdominal segments less densely spinose; striations of lateral margins of epipharynx distinct, epipharynx with a submarginal, distal row of striæ (sometimes difficult to observe in some species).....*Phyllophaga*

3. Epipharynx with three strong spines in distal sensory area; radula with a conspicuous transverse row of spines.....*Serica*
   Epipharynx with four strong spines in distal sensory area..... 4
4. Setæ of radula not hooked at the tip; presence or absence of double longitudinal rows of spines on radula questionable.* Distal end of abdomen sparsely clothed with shorter, stronger setæ; claws of posterior tarsi less than half as long as those of other tarsi.....*Diplotaxis*
   Setæ of radula hooked at the tip; radula with a short, double row of longitudinal spines; distal end of abdomen densely clothed with long, delicate setæ; anal opening sharply acute; claws of posterior tarsi equal in length to claws of other tarsi.....*Macrodactylus*

LARVAL KEY TO GENERA OF SUBFAMILY RUTELINÆ.

1. Ental aspect of the labrum with a series of transverse striæ on the lateral margins near bases of lateral setæ.....Tribe *Anomalini*. 2
   Labrum without such transverse striæ on its ental lateral margins, Tribe *Rutelini*. 4
2. With two of the four spines of the distal sensory area of the epipharynx strongly fused at the base making a large spine with its distal end bifid; longitudinal, double row of spines of radula parallel, not divergent, with eight spines in the left row and nine in the right row..*Strigoderma arboricola*
   Without two spines of the distal sensory area of the epipharynx fused at base to form a bifid spine; longitudinal double row of spines of the radula either parallel or diverging posteriorly..... 3
3. Radula with longitudinal rows of spines short, about seven spines in each row; rows strongly divergent posteriorly; sensillia of distal sensory area of epipharynx at bases of distal spines about equal in size and arranged nearly semicircularly.....*Popillia japonica*
   Radula with longitudinal rows of spines usually longer, with twelve to thirteen spines in each row; rows more or less parallel and frequently converging posteriorly; sensillia of distal sensory area of epipharynx at bases of distal spines unequal in size and not arranged as definitely in a semicircle.....*Anomala*
4. Larvæ found in rotten logs or stumps, sometimes under dried manure, labrum wider than long, with or without two longitudinal rows of spines on radula; setæ of lateral margins of labrum of various lengths, but not strongly curved..... 5
   Larvæ usually formed in sandy soils, labrum as long as wide, strongly rounded but asymmetrical, without longitudinal rows of spines on radula; lateral margins of labrum with strongly curved, flattened setæ which increase in length distally.....*Cotalpa lanigera*
5. Larvæ found in rotten logs or stumps, without two longitudinal rows of spines on radula, distal sensory area not produced into a single large, chitinous tubercle, without semicircular ring at base.....*Pelidnota punctata*
   Larvæ under rotten logs or stumps, or under dried manure on sandy soils; with two longitudinal rows of spines on radula; distal sensory area produced into a single large chitinous tubercle, having between its base and the distal margin a narrow chitinous semicircle..*Polymœchus brevipes*

LARVAL KEY TO GENERA OF SUBFAMILY DYNASTINÆ.

1. With a single ocellar spot at base of antenna..... 2
   Without an ocellar spot at base of antenna..... 4
2. Radula with a longitudinal cleared area surrounded by recumbent spines similar to other spines of radula, spines not strongly differentiated as in other subfamilies having the double longitudinal row of spines; usually found in manure.....*Ligyrodes* (*Ligyrus*) *relictus*

*The only specimen of "*Diplotaxis*" available does not show the radula distinctly. A specimen in the Illinois Natural History Survey Collection labeled "Diplotaxis" is apparently a species of *Serica*.

Radula without such a longitudinal, non-setose area formed by the absence of spines or setæ..... 3

3. Distal sensory area of epipharynx produced into a long, proximal pointing, chitinous process which is curved at its apex, at its base are numerous large setæ; head brownish-tan in color; usually found in burrows near manure.....*Strategus*

Distal sensory area of epipharynx not produced into a long, proximal pointing, chitinous process nearly devoid of setæ in the region of the distal sensory area; head nearly black in color, densely punctate; usually found on soil among dead leaves in woods.....*Xyloryctes*

4. Epipharynx with the chitinous portion of the distal sensory area produced to form a single broad tubercle; labrum strongly asymmetrical; sides of labrum strongly rounded; setæ of radula very short, not hooked, *Ligyrus gibbosus*

Epipharynx with the chitinous portion of the distal sensory area produced to form two tubercles or spines, labrum more nearly symmetrical; sides of labrum less rounded..... 5

5. Distal sensory area of the epipharynx produced in the form of two broad tubercles close to the distal margin of the labrum; head and mandibles almost black in color; head strongly punctured; prothorax with a large, brown, more heavily chitinized area on the sides, which is deeply bipunctate; usually extremely large grubs.....*Dynastes tityrus*

Distal sensory area of the epipharynx produced in the form of two small spines and more remote from the distal margin of the labrum; head yellow in color; sparsely and finely punctate; prothorax without brown, chitinous areas on sides; never extremely large grubs. *Ochrosidia* (*Cyclocephala*) *immaculata**

LARVAL KEY TO GENERA OF SUBFAMILY CETONIINÆ.

1. Labrum almost as long as wide, not distinctly trilobed; emarginations of labrum relatively shallow; a distinct ocellar spot at base of each antenna; distal sensory area of epipharynx produced into a conspicuous chitinous tubercle; larvæ live in wood.....*Trichiotinus*

Labrum considerably wider than long, distinctly trilobed, relatively deeply emarginate, no ocellar spot at base of antenna; distal sensory area not produced into a chitinous tubercle; larvæ live in various situations, one genus, (*Osmoderma*), in wood..... 2

2. Epipharynx with a chitinous, semi-circular carina near distal margin of the median lobe; proximad of this ridge is a semi-circle of about sixteen sensory pores.† On the side of the epipharynx additional pores apparently make the semi-circle continuous almost to the clypeo-labral suture; tarsal claws normal, curved and sharply pointed; larvæ live in ant nests.....*Cremastocheilus*

Epipharynx without a chitinous, semi-circular carina on distal margin of median lobe; the median lobe is provided with a conspicuous semi-circle of spines; tarsal claws usually modified into blunt, cylindrical, setaceous tubercles‡..... 3

**Dyscinetus* has not been studied. Davis (1916) states that *D. trachypygus* has "a dark brown head which is inconspicuously reticulate and covered with irregularly placed fine punctures, in this respect differing from all species (which he mentions) except *Strategus*, the head of which is much more coarsely punctate and the species is much larger. The ventral surface of the anal segment bears a patch of hooked spines and the upper surface of the same segment is covered, excepting along the median line, with fine hairs, those at the tip being shorter, stouter and more spine-like."

†In the only specimen available for study the epipharynx is almost devoid of setæ, but in their place numerous pores are present which may be trichopores whose setæ have been lost, or they may in fact be sensillia.

‡Claws of *Stephanucha* have not been examined.

3. Epipharynx with about ten spines in a semicircular row in distal sensory area; placed somewhat obliquely; no chitinous sensory tubercle in proximal sensory area near clypeo-labral suture mesad of tormæ; larvæ live in sandy soil (rare).....*Stephanucha*
   Epipharynx usually with more than ten spines (about 15–17) in a semicircular row in distal sensory area, placed almost transversely; with a well defined sensory tubercle in proximal sensory area near clypeo-labral suture; larvæ crawl on their backs..... 4
4. Radula of last abdominal segment with spines of the longitudinal rows short, separated from each other by a distance nearly equal to the length of the spines; apices of opposing spines distant from each other by less than the length of an individual spine; spines about twice as long as their width at base; antepenultimate antennal segment longer than the terminal segment; usually found in rich, sandy or loam soil.....*Cotinis*
   Radula of last abdominal segment with spines of longitudinal rows longer, separated from each other by a distance much less than the length of the spines; apices of opposing spines separated from each other by a distance greater than the length of an individual spine; spines considerably more than twice as long as width at base; antepenultimate antennal segment as long as, or shorter, than the terminal segment; larvæ usually found in manure.....*Euphoria*. 5
5. Radula of last abdominal segment with spines of longitudinal rows diverging posteriorly.....*Euphoria sepulchralis*
   Radula of last abdominal segment with spines of longitudinal rows converging posteriorly.....*Euphoria inda* and *Euphoria fulgida*

LARVAL KEY TO GENERA OF FAMILY LUCANIDÆ.

1. Antennæ five-segmented..... 2
   Antennæ four-segmented..... 3
2. Dorsal lobe of the three anal lobes acutely pointed on its ventral margin, lateral lobes with a concentric oval line.....*Dorcus*
   Dorsal lobe of the three anal lobes with its ventral margin strongly rounded; lateral lobes without a concentric oval line.....*Lucanus*
3. Caudal region of radula of the last ventral segment with spinose setæ; anal opening on each side.....*Platycerus**
   Caudal region of radula without spinose setæ..... 4
4. Lateral lobes of anus large, subtriangular, not emarginate at their ventral point of union; superior lobe large.....*Ceruchus*
   Lateral lobes of anus plainly elliptical, emarginate at their ventral point of union; superior lobe small.....*Sinodendron*

*Genus not seen. The characters given above are from Perris (1877) after Mulsant.

REFERENCES CITED.

Boving, A. G. 1921. The larva of Popillia japonica Newman and a closely related undetermined ruteline larva. A systematic and morphological study. In Proc. Ent. Soc. Wash., Vol. 23, pp. 51-62, 2 pl.

Burmeister, H. C. C. 1842. Handbuch der Entom. Vol. 3, pp. 55-68; Berlin, Reimer, 1832-1855.

Chapuis, M. F. and **Candeze, M. E.** 1855. Catalogue des larves des coleoptères connues jusqua ce jour avec la description de plusieurs especes nouvelles. Mem. Soc. Scien. Liege, Vol. 8, pp. 341-653, (also appeared as a separate).

Davis, J. J. 1916. A progress report on white grub investigations. In Journ. Econ. Ent. 9: 261-281, 3 pl.

DeHaan, W. 1836. Memoires sur les metamorphoses des coleoptères. Nouv. Ann. Mus. Nat. Hist., Vol. 4, p. 125, (also appeared as a separate).

Erickson, W. F. 1848. Naturgeschichte der Insecten Deutschlands, Erste Abt. Coleop., Vol. 3, Berlin, Nicolai 968 pp.

Forbes, S. A. 1894. Eighteenth report of the state entomologist on the noxious and beneficial insects of the State of Illinois; seventh report of S. A. Forbes for the years 1891 and 1892. Springfield, Ill., State Printer, 171 pp. XIII.

Hayes, W. P. 1927. The immature stages and larval anatomy of Anomala kansana H. and Mc. C. (Scarabæidæ, Coleop.). In Ann. Ent. Soc. Amer., 20: 193-203, 3 pl.

Mulsant, E. 1842. Histoire naturelle des Coleoptères de France, Part II. Lyon (et Paris), Maison. 8, later Paris, Magnen and Blanchard Co. Part 2, Lamellicornes, 624 pp. 3 pl.

Perris, E. 1877. Larves des Coleoptères. Paris, Deyrolle, naturaliste, 1877, 590 pp, 14 pl. (Lamellicorns, pp. 91-122 and pls. 4-5).

Ritterschaus, K. 1927. Studien zur morphologie und biologie von Phyllopertha horticola L. und Anomala aenea Geer (Coleop.). In Zeits. Wiss. Biol., Abt. A. Zeits. Morph and Okol. Tiere, 8: 271-408.

Schiodte, I. C. 1874. De metamorphosi Euleutheratorum observations. Naturalist. Tiddskrift, series 3. Vol. 9, pp. 227-376, pl. VIII-XIX.

NOTE.—The following references are cited by Hatch (Journ. N. Y. Ent. Soc., Vol. 35, 1927) as treating of scarabæidæ larvæ. They have not been seen by the writer.

Fowler, W. W. 1912. Coleoptera: General Introduction, Fauna of Brit. India, London, XX, 529 pp. (Discusses groups of Scarabæid larvæ, p. 203).

Henricksen, K. 1925. (Families of Scarabæid Larvæ). Denmark's Fauna. Biller VI, p. 135; 143-153 and 159-165.

EXPLANATION OF PLATES.

PLATE XV.

Figs. 1–11. Epipharynx of Melolonthinæ.
Figs. 12–13. Epipharynx of Lucanidæ.
Fig. 14. Epipharynx of Passalidæ.
Fig. 15. Epipharynx of Trogidæ.

PLATE XVI.

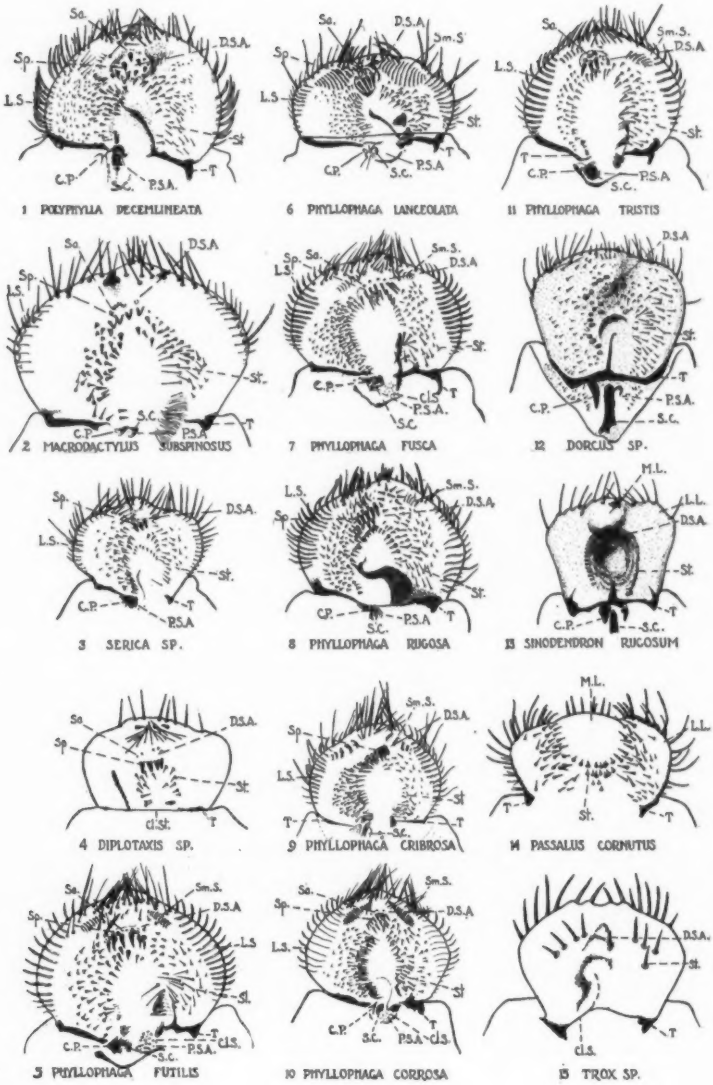
Figs. 16–21. Epipharynx of tribe Anomalini, Rutelinæ.
Figs. 22–24. Epipharynx of tribe Rutelini, Rutelinæ.
Figs. 25–30. Epipharynx of Dynastinæ.

PLATE XVII.

Figs. 31–36. Epipharynx of Laparosticti.
Figs. 37–44. Epipharynx of Cetoniinæ.
Fig. 45. The sense cone in the proximal sensory area of *Phyllophaga futilis*. st., setæ; s. c., sense-cone; sa., sensilla showing as a knobbed process at the bottom of a pore.

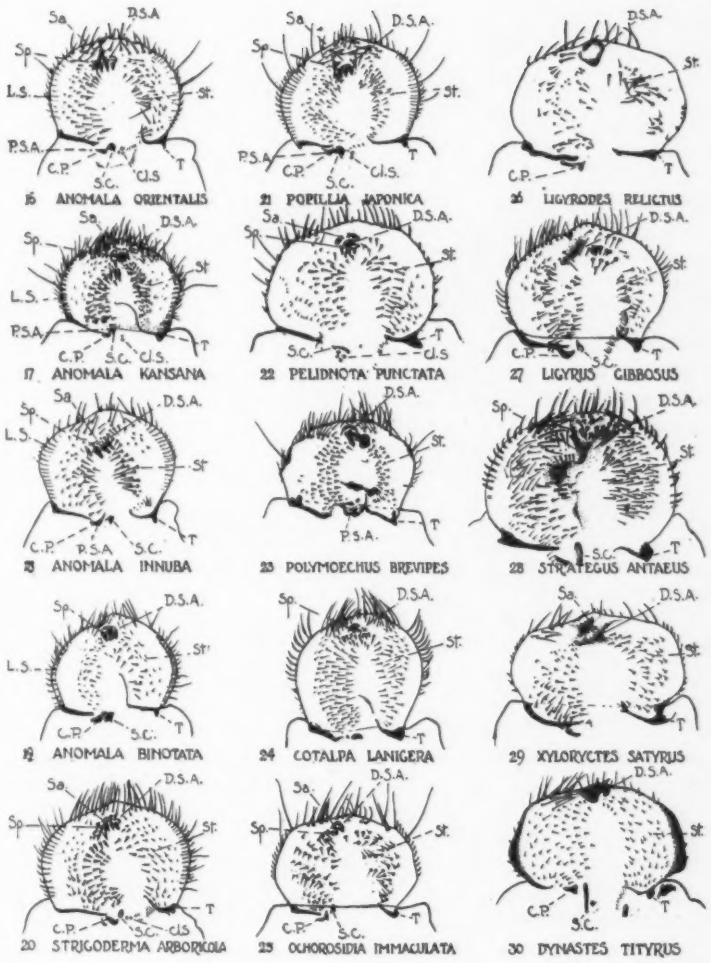
EXPLANATION OF ABBREVIATIONS.

c. p.....chitinous plate.
cl. s.....clypeal sensillia.
cl. st.....clypeo-labral suture.
d. s. a.....distal sensory area.
l. l.....lateral lobe.
l. s.....lateral striæ.
m. l.....median lobe.
p. s. a.....proximal sensory area.
sa.....sensillia.
s. c.....sense-cone.
sm. s.....submarginal striæ.
sp.....spines.
st.....setæ.
t.....torma.

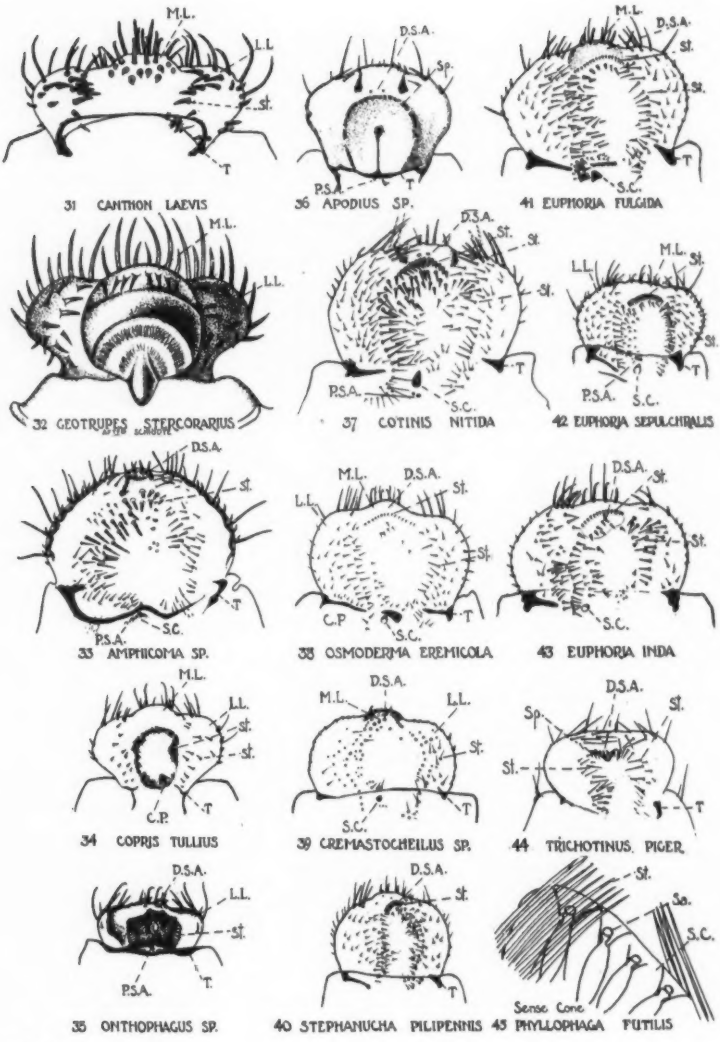


1 POLYPHYLLA DECEMLINEATA
6 PHYLLOPHAGA LANCEOLATA
11 PHYLLOPHAGA TRISTIS
2 MACRODACTYLUS SUBSPINOSUS
7 PHYLLOPHAGA FUSCA
12 DORCUS SP.
3 SERICA SP.
8 PHYLLOPHAGA RUGOSA
13 SINODENDRON RUGOSUM
4 DIPLOTAXIS SP.
9 PHYLLOPHAGA CRIBROSA
14 PASSALUS CORNUTUS
5 PHYLLOPHAGA FUTILIS
10 PHYLLOPHAGA CORROSA
15 TROX SP.

W. P. Hayes


Sa.
D.S.A.
Sp.
L.S.
St.
P.S.A.
C.P.
S.C.
Cl.S.
T
16 ANOMALA ORIENTALIS
21 POPILLIA JAPONICA
26 LIGYRODES RELICTUS
17 ANOMALA KANSANA
22 PELIDNOTA PUNCTATA
27 LIGYRUS GIBBOSUS
18 ANOMALA INNUBA
23 POLYMOECHUS BREVIPES
28 STRATEGUS ANTAEUS
19 ANOMALA BINOTATA
24 COTALPA LANIGERA
29 XYLORYCTES SATYRUS
20 STRIGODERMA ARBORICOLA
25 OCHROSIDIA IMMACULATA
30 DYNASTES TITYRUS

W. P. Hayes


M.L.
L.L.
St.
T
31 CANTHON LAEVIS
D.S.A.
Sp.
P.S.A.
T
36 APODIUS SP.
M.L.
D.S.A.
St.
St.
T
S.C.
41 EUPHORIA FULGIDA
M.L.
L.L.
32 GEOTRUPES STERCORARIUS
D.S.A.
St.
St.
St.
T
P.S.A.
S.C.
37 COTINIS NITIDA
M.L.
St.
L.L.
St.
T
P.S.A.
S.C.
42 EUPHORIA SEPULCHRALIS
D.S.A.
St.
T
P.S.A.
S.C.
33 AMPHICOMA SP.
M.L.
D.S.A.
St.
L.L.
St.
C.P
S.C.
T
38 OSMODERMA EREMICOLA
D.S.A.
St.
St.
S.C.
43 EUPHORIA INDA
M.L.
L.L.
St.
St.
C.P.
T
34 COPRIS TULLIUS
D.S.A.
M.L.
L.L.
St.
S.C.
T
39 CREMASTOCHEILUS SP.
D.S.A.
Sp.
St.
St.
T
44 TRICHOTINUS. PIGER.
D.S.A.
L.L.
St.
P.S.A.
T
35 ONTHOPHAGUS SP.
D.S.A.
St.
T
40 STEPHANUCHA PILIPENNIS
St.
Se.
S.C.
Sense Cone
45 PHYLLOPHAGA FUTILIS

W. P. Hayes

THE BIOLOGY OF TAPINOMA SESSILE SAY, AN IMPORTANT HOUSE-INFESTING ANT.*†

MARION R. SMITH,
A. and M. College, Mississippi.

INTRODUCTION.

The ant, *Tapinoma sessile* Say, a common and widely distributed North American species, has been known to entomologists since 1836, yet it has not been mentioned in literature as an economic species until within comparatively recent years.

The writer first became aware of the ant as a house pest in 1921. Its importance as such was scarcely recognized by him until 1924 and 1925 when he found this species to be the most important of all house infesting ants at Urbana, Illinois. The ant was found in houses in nearly every block investigated and in some blocks as high as 80 to 90 percent of the homes were infested. Inquiries concerning the relative importance, the biology, and the control of this ant were then sent to entomologists in all sections of North America. Replies received in response to the questionnaries showed the ant to be a house infesting species in the following localities: California, Nevada, District of Columbia, Maryland, Tennessee, and Mississippi. The ant is very probably a pest in a number of localities from which no reports are available. In California this ant appears to be an especially serious house pest. Essig in a letter stated that 50 percent of the trouble from house infesting ants in the western section of that state was due to this one species.

COMMON NAME.

This ant passed for many years without a common name until Essig named it, the odorous ant, because of the unpleasant,

*An abstract of a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Entomology in the Graduate School of the University of Illinois, 1927.

†Contributions from the Entomological Laboratories of the University of Illinois, No. 122.

nauseating, Tapinoma-like smell which it produces. This rather descriptive name is objectionable in that there are other Dolichoderinid ants having a similar odor, which might be confused with this species. The writer would further restrict the name, and call the species, the odorous house ant. In the New England and North Central States, so far as the writer is aware, there are no other Dolichoderinid house infesting ants. In the Southern States east of the Mississippi River species related to *Tapinoma sessile* Say are not common house pests, excepting the Argentine ant, *Iridomyrmex humilis* Mayr, an imported species. The writer fully realizes the name is still open to objection in that there are a number of Dolichoderinid ants which are bad house pests in the Southwestern States; however, for want of a better name the ant will be referred to throughout this paper as the odorous house ant.

SYNONYMY AND DESCRIPTION.

The odorous house ant was described by Thomas Say as *Formica sessilis* in the Boston Journal of Natural History, Volume 1, page 287 for May, 1836, the description being based on Indiana specimens. Say's specimens are now nonexistent. His descriptions, although possessing some very salient characters is too brief and inadequate for an ant which is so highly variable in color, size, and pubescence as is the odorous house ant. The writer has redescribed the species from specimens taken at Urbana, Illinois. He believes that the specimens from which he has drawn his descriptions are very similar to those of Say's since Indiana and Illinois are contiguous.

Below is the synonymy of this species, followed by the author's description of the ant.

Formica sessilis Say, Boston Jour. Nat. Hist., Vol. 1, p. 287 (1836) female and worker.

Tapinoma sessilis Fred Smith, Cat. Hym. Brit. Mus., Vol. 6, p. 57 (1858).

Tapinoma sessile Mayr, Verh. Zool.—bot. Ges. Wien., Vol. 36, p. 434 (1886); Emery, Zool. Jahrb. Syst., Vol. 8, p. 332 (1895), female and male.

Tapinoma boreale Roger, Berl. Ent. Zeitschr., Vol. 7, p. 165 (1863), female and worker; Mayr, Sitz. Akad. Wiss. Wien., Vol. 53, p. 397 (1866), worker.

Formica gracilis Buckley, Proc. Ent. Soc. Phila., Vol. 6, p. 158 (1866) worker, female.

Formica parva Buckley, ibidem, Vol. 6, p. 159 (1866) worker.

Worker. Length, 2.39–3.19 mm. (Plate XVIII, Fig. 1).

Head oval, broader behind than in front, with faintly emarginate posterior border, rounded posterior angles and convex sides. Mandibles with the teeth almost gradually and uniformly diminishing in size from the apex to the superior border, the 3 or 4 apical teeth larger and more distinct than the others. Eyes moderately convex, placed at a distance from the mandibles equivalent to their greatest diameter. Clypeus convex, the anterior border distinctly excised medianly, the posterior border broadly rounded and extending for some distance between the bases of the frontal carinæ. Frontal area obsolete. Antennal scapes surpassing the posterior angles of the head by almost one-fourth their length. Thorax short and robust, anteriorly narrower than the head. Pro-mesonotal and meso-epinotal sutures very distinct. Viewed laterally, the pro- and mesonotum together form a rather long, gentle arch, which terminates at the meso-epinotal constriction; from the latter arises a short but gentle arch, which gradually fuses into the straight, oblique, declivous surface of the epinotum. Petiole not strongly developed, inclined forward and usually concealed by the basal surface of the abdomen which is superimposed upon it. Gaster subelliptical, broadest at the base and tapering apically; with four distinct segments, the remaining segments concealed; basal surface of the gaster with a wedge-shaped impression for the reception of the petiole.

Body minutely shagreened, subopaque and slightly glossy. Mandibles and anterior border of head more shining, the former with distinct scattered punctures.

Hairs sparse, light yellowish, erect, confined to the mandibles, clypeus, prosternum, coxæ, and the ventral surface of the gaster and dorsal surface of the fourth segment. Pubescence grayish, fine, yet distinct, and closely appressed to the body, giving the body a general pruinose tinge.

Body deep brown to black; mandibles and appendages lighter, especially the tibiæ and tarsi of the legs.

Dealated Female. Length, 3.75–4.29 mm. (Plate XVIII, Fig. 2).

Head, excluding the mandibles, subquadrate, about as broad as long, widest posteriorly, with rounded posterior angles, faintly excised posterior border and subparallel sides. Eyes large, rather convex, placed at a distance from the mandibles equivalent to less than their greatest diameter. Mandibles and clypeus similar to that of the worker. Antennæ proportionally stouter than in the worker, the scapes surpassing the posterior corners of the head by almost one-fourth their length. Thorax short and robust; through its greatest breadth about as broad as the posterior region of the head. Mesonotum, mesoparaptera and scutellum distinctly flattened dorsally, mesonotum laterally with a distinct parapsidal furrow on each side. Basal surface of the epinotum short, gently convex, not over one-half as long as the oblique, declivous surface, into which it gradually merges. (Wings, when present, of the same character as in the male). Scale of petiole not highly developed, inclined forward and hidden beneath the basal

surface of the gaster, which is somewhat superimposed upon it. Legs of moderate size, distal ends of each tibia with a spur, that of the prolegs clearly pectinate. Gaster subelliptical, broadest basally and tapering apically, with four distinct segments dorsally, the others concealed; base of gaster with a wedge-shaped depression for the reception of the petiole.

Sculpturing similar to that of the worker.

Pilosity similar to that of the worker; the anterior border of the clypeus with a long distinct hair on each side of the median excision. Pubescence yellowish or grayish, according to the light, and longer and more distinct over all parts of the body than on the worker, thus giving the body a more subopaque, pruinose tinge.

Body varying from brown to almost black; thorax and appendages lighter, especially the latter.

Alate Male. Length, 3.60–4.44 mm. (Plate XVIII, Fig. 3).

Head, excluding the mandibles, subquadrate, broader behind than in front of the eyes, the posterior border faintly convex, the posterior corners subangular. Mandibles with one large apical and several subequal denticulæ. Maxillary palpi 6-segmented, labial palpi 4-segmented, as in the worker and female. Clypeus moderately convex, the anterior border with a faint central excision, the posterior border broadly rounded and extending some distance between the frontal carinæ. Eyes elliptical, very large and strongly convex. Vertex with 3 prominent ocelli, the distance between the two ocelli approximately twice as great as that between one of the lateral and the median ocellus. Antennæ 13-segmented, the scapes surpassing the posterior corners of the head by about one-fourth their length. Mesonotum large, flattened dorsally, and with a parapsidal furrow on each side, but without Mayrian furrows. Wings sordid gray, thickly pilose, and with ciliated margins, the veins yellowish-brown. Anterior pair of wings each with a single closed discoidal cell, cubital cell, and radial cell, the discoidal cell subquadrate. Epinotum with the base and declivity so completely fusing that the limits of each are not definitely discernible, the two forming a rather gentle, convex surface. Legs moderate in size, the distal ends of each tibia with a spur. Petiole inclined forward, but concealed for the most part by the base of the gaster which is superimposed upon it. Gaster elongate elliptical, with a wedge-shaped impression at the base for the reception of the petiole. Genitalia rather large and prominent, stipites large and subtriangular, the cerci each with a tuft of hairs or cilia at their distal ends.

Pilosity resembling that of the worker and female, but different in lacking hairs on the dorsum of the fourth segment, which are here confined for the most part to the stipites of the genitalia and the cerci. Body covered with dense, grayish pubescence, which is most discernible on the appendages. In certain lights the pubescence of the body has a slight, somewhat subopaque luster. The petiole is free of pubescence and is therefore smooth and glabrous.

Body uniform deep brown to almost black; the mandibles and appendages scarcely or not at all paler in color.

CLASSIFICATION.

The odorous house ant is a member of the subfamily *Dolichoderinæ*, which in North America embraces seven genera. The ants of this subfamily are characterized (1) by the presence of a ventral, slit-shaped, cloacal orifice; (2) by the presence of anal glands which produce a secretion having a rotten cocoanut or nauseating Tapinoma-like odor; (3) by the presence of a single-segmented abdominal pedicel, and (4) by the fact that the pupæ are not enclosed in cocoons.

The food of the ants of this family is small organisms, supplemented by honeydew, and the floral, extrafloral and glandular excretions of plants. A number of species are important house pests: among these being, the Argentine ant, *Iridomyrmex humilis* Mayr; the odorous house ant, *Tapinoma sessile* Say; and the species, *Tapinoma melanocephalum* Fabricius. The Argentine ant is without doubt, one of the worst house infesting ants in the world.

Worker ants of the genus *Tapinoma* can be distinguished from the workers of closely related genera in that the abdominal pedicel bears a vestigial scale or petiole, which is overshadowed by the base of the abdomen.

Only three species of *Tapinoma* are definitely known to occur in North America, and all of these except one are native species. The following key will suffice for the determination of the workers.

KEY TO WORKERS OF THE NORTH AMERICAN SPECIES OF TAPINOMA.

1. Workers small, never measuring more than 1.5 mm. in length..... 2
   Workers larger, measuring at least 2 mm. or more in length; color varying from brown to black, appendages lighter; antennal scapes surpassing the posterior corners of the head; most common species.....*sessile* Say
2. Antennal scapes surpassing the posterior corners of the head; head and thorax very distinctly brown, mandibles, antennæ and legs very pale yellowish; imported species.....*melanocephalum* Fabr.
   Antennal scapes not attaining the posterior corners of the head; general color pale yellow, sometimes, however, with the dorsal surfaces of the body brownish; native species, at present only recorded from the coast of Florida.....*litorale* Wheeler

A species which has been passing in literature for sometime as *Tapinoma pruinosus* Roger was described by Roger in 1866 from Cuban specimens (*Tapinoma pruinosum*, Roger, Berl. Ent. Zeitschr. Vol. 7, p. 165 (1866)). Wheeler in his bulletin on the ants of Cuba (Bull. Mus. Comp. Zool. Harvard, Vol. 54, p. 497 1913) has shown that the ants which have been passing

as *Tapinoma pruinosus* Roger are really *Iridomyrmex pruinosus* (Roger), a species common to the United States as well as to Cuba. The name *Tapinoma pruinosus* Roger is therefore relegated to synonymy and the name *Iridomyrmex pruinosus* (Roger) succeeds it.

On page 16 of this paper, the writer mentions a species of ant which Wheeler described from Massachusetts as *Bothriomyrmex dimmocki*. Wheeler in remarking about the ant mentions the fact that he was very much surprised to find a species of *Bothriomyrmex* occurring in North America as no species had been previously recorded for this country.

According to the opinion of Emery the ant should be transferred to the genus *Tapinoma* (Emery, Bull. Soc. vaud. Sci. Nat. Vol. 56, p. 19, 1925). Since the writer does not posess Emery's paper he does not know what reasons the author gives for such a change. To the writer it would appear that Wheeler was correct in placing this species in the genus *Bothriomyrmex* as the workers which he described had 4 segmented maxillary palpi and not 6 segmented as do the species of *Tapinoma*. Wheeler does not mention whether the scale of the abdominal pedicel of the workers was distinct or not; if it was distinct, then the workers of this species would appear unquestionably to belong to *Bothriomyrmex*, since the scale of *Tapinoma* is vestigial. The writer has followed Wheeler for the reasons stated and has therefore not considered *dimmocki* a species of *Tapinoma* as Emery does.

METHODS OF CONDUCTING THE BIOLOGICAL STUDY.

Ants collected in the field, were brought to the laboratory where they were etherized, counted, and placed in the cages for observations. These plaster of Paris cages consisted of two small, rectangular, intercommunicating chambers which were covered by a small pane of glass upon which was a heavy piece of carboard. The glass and cardboard not only prevented the ants from escaping, but held in the moisture and made the cages dark. Food, consisting of nuts, meats, cooked eggs, honey, and sugar, was placed in one of the compartments of the cage as needed. Since the food would quickly mold it was necessary to change it every other day. Observations on the number of eggs laid from day to day and on the develop-

ment of the ants were recorded and compared with field observations.

In computing the development of the brood, it was necessary to assume that the first eggs laid were the first to hatch, and that the first to hatch, were the first to pupate, etc. This method, though open to some objections, is the only practical means of ascertaining the life history of so complex a social insect, inasmuch as it is constantly moving its eggs and brood or even at times devouring them.

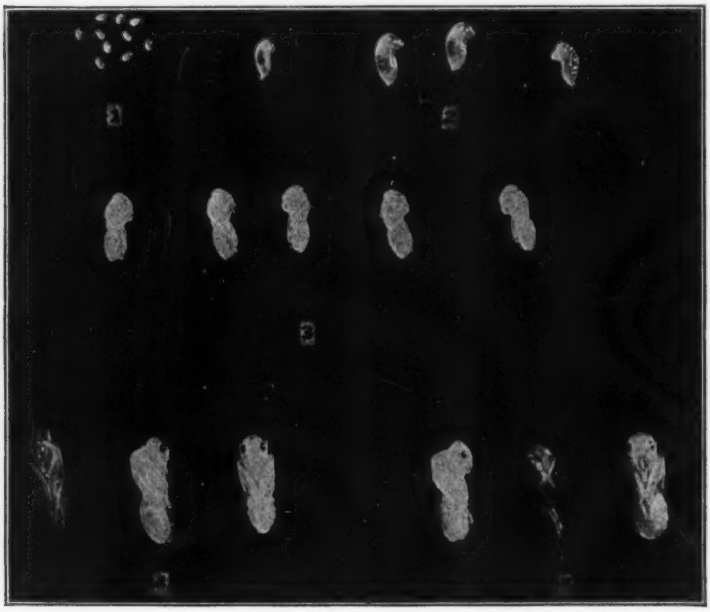
SEASONAL HISTORY.

Indoors in apartment houses, single residences, greenhouses, and other places where the temperature is optimum, the workers are active the year around, and very probably breeding operations also take place continuously. Due to the inaccessibility of such nests, no examinations could be made to determine whether development of the brood was taking place or not. Dealated females that were brought to the laboratory in late fall and kept at a temperature of 70 degrees Fahrenheit, or above, laid a few eggs, which took from twenty-two to twenty-six days to hatch, and the larvæ developing from these eggs made no satisfactory growth until spring.

Outdoors, on the other hand, the odorous house ant passes the winter as workers, dealate females, and partly grown larvæ. Workers began foraging as early as March 7th. Egg laying and uniform development of the brood were continuous processes from late April till cold weather, approximately November 1st. After a dormant period from November till April, the partly grown larvæ appeared as workers during April, thus requiring six to seven months for their complete life history. For eggs laid from April to June, development of the workers took place in from five to nine weeks. For eggs laid from June to September development proceeded even faster than this, requiring only six to seven weeks. No observations were made on the development of the males and females.

Alate females have been observed by the writer and others to appear at various dates ranging from June 17th to early July, and males have been noted from June 10th to July 9th. From the data available it appears that the males emerge a short time before the females. Mating is believed to take place both inside the nest and outside of it. That mating may

take place in the nest is indicated by the finding of partly and wholly dealated females there as well as freshly discarded wings. If mating takes place in the nest it is very probable that there is considerable inbreeding in this species. Such may account for the large number of dealated females to be found in the nest. Young colonies are apparently not capable of producing sexed forms, for of the many colonies examined only two large,



Tapinoma sessile Say.

Fig. 1—Eggs, × 4. Fig. 2—Worker larvæ, × 4. Fig. 3—Male pupæ, × 4. Figs. 4 and 5—Female pupæ, × 4.

(Photographs by the Department of Photography, University of Illinois)

populous ones contained sexed forms. The males are very short-lived and have never been found in the nest except for the period during which they are attaining sexual maturity. Many winged males and females have been captured outside the nest, where some of these no doubt mated. Wheeler states that he has seen females of *Tapinoma** establishing their

*Very probably *sessile* Say.—AUTHOR.

nests independently, but the writer has not been so fortunate as to observe this. That young females of the current season begin egg laying soon after fertilization has been proven by the writer who kept such females in artificial nests and has obtained eggs from them.

Since the breeding season lasts from April to November and since the average time required for the development of the worker in summer is seven weeks, four to five generations a year is postulated.

DEVELOPMENT OF THE WORKER FROM EGG TO ADULT.

The egg of the odorous house ant is subelliptical in form, pearly white in color, lustrous, and without markings. It measures .24 by .39 mm. The egg membrane is thin and easily ruptured. It is also of such a sticky nature that one egg easily adheres to another. In the process of incubation the egg gradually loses its luster, becomes more opaque, and eventually the form of the developing embryo can be distinguished. Incubation requires from eleven to twenty-six days according to the season of the year (Fig. 1).

The freshly hatched larva is scarcely larger than the egg. As the larva grows its head becomes recurved ventrally, and a peculiar protuberance can be noted on the superior surface of the caudal end of the body. The body of the larva is distinctly segmented and also somewhat yellowish in color. Beneath the integument are small, scattered, white particles, probably excretory products. When full grown the larva is rather plump, being less distinctly segmented dorsally. The meconium is now quite apparent. The head of the larva appears even more recurved than formerly, and the caudal protuberance is very clearly evident. The larva now measures .72 by 1.74 mm. The larval stage occupies from thirteen to twenty-nine days (Fig. 2).

The prepupa is an almost exact replica of the full grown larva except that the meconium is not evident, it having been cast out just before the larva went into this stage. The body is robust and very plump. The integument soon accquires a much wrinkled, dry appearance. The prepupa measures about 1.8 mm. in length. The prepupal stage requires from two to three days.

The worker pupa when first formed is naked, white, and destitute of any color markings. It measures from 1.82 to 2.29 mm. in length. The head is directed ventrad, and the appendages are borne very close to the ventral surface of the body as in the usual manner. The eyes of the pupa begin to show a faint brown in color in from two to three days, and in from six to nine days not only are the eyes black but the mandibles are brown and the body has accquired a sordid yellowish tinge, the gaster being more infuscated and the head less so. The pupal stage lasts from eight to twenty-five days, averaging in midsummer about fourteen days (Fig. 3).

TABLE I.

The Maximum, Average, and Minimum Time Required for the Workers to Develop from Egg to Adult at Various Seasons of the Year.

Season	Maximum Number Days	Average Number Days	Minimum Number Days	Number Specimens Observed
April-June Egg Stage.....	20	15	12	15
*Larval Stage.....	29	22	13	8
Prepupal Stage.....	....	....	....	....
Pupal Stage.....	18	13	6	35
Total—Egg to Adult....	67	50	31	....
July-September Egg Stage.	16	12	11	28
Larval Stage.....	16	15	14	3
Prepupal Stage.....	3	2	2	7
Pupal Stage.....	25	13	8	....
Total—Egg to Adult....	60	42	35	....

Three days after emergence the gaster of the callow is deeply infuscated, the head less so, and the thorax least of all. The time required for the callow to attain full color in the life history cages has ranged over wide limits, usually averaging from less than a week to more than three weeks.

LENGTH OF LIFE OF THE VARIOUS CASTES.

Very little informations was obtained on the length of adult life of the various castes. One female was kept eight months, the longest period observed, and was then accidentally

*This is the time required for the combined larval and prepupal stages.

killed by crushing. Many of the females brought in from the field died in a period of a few weeks to several months. Death in many cases was due to unsatisfactory cage conditions, such as the development of mold, etc. Workers appear to be as hardy as females and lived equally long. In cages the males on the other hand, are very short-lived, perishing within a week or ten days. During confinement they seemed to have exhausted themselves by running nervously about. Under natural conditions the females probably live a number of years, as do the workers, whereas the males perish within a few days after emergence.

HARDINESS OF THE ANTS.

The hardiness of the ants is most remarkable. On a number of occasions the writer has accidentally broken off appendages, or even crushed the bodies of the female and workers, yet these specimens lived and appeared to be little affected by the injuries. Some females with considerably crushed abdomens have laid eggs in spite of their injuries. In one case, two dealated females without food or water, survived confinement in a jar for a period of over two months.

THE EGG LAYING CAPACITY OF THE FEMALE.

Tapinoma sessile Say is remarkable in that there are so many dealated females in each colony, in some nests as many as two hundred, all apparently taking part in brood production. The females, although considerably larger than the workers, are not so much so as in other species. Females kept in life history cages over a considerable period of time have laid only a very small number of eggs. Sometimes an individual has laid as many as twenty to thirty eggs a day, but when an egg count was kept over a long period of time it was found that the total number of eggs produced by each female was comparatively small; some averaged not over .03 eggs a day, whereas the most prolific layers averaged only 1.78 eggs a day. Assuming that a female begins egg laying in April and lays 1.78 eggs per day up to the first of October, she will have laid only 350 eggs, a very small number. Although the records mentioned above were obtained under artificial conditions, the writer believes they closely approximate those in nature. The small size of the females and the great number in each nest very clearly

indicate that the females are individually not large egg layers, and that the flourishing condition of the colony is due to the combined output of many females (Table 2).

REPRODUCTIVE ABILITY OF THE WORKERS.

Egg laying by the workers has been observed on three different occasions, indicating a not uncommon habit of this caste. A number of workers without a female, which were confined in a cage on May 7th, laid twenty-one eggs by the

TABLE II.

The Total Number of Eggs Laid by Each Female, the Number of Days Each Female Was Kept in Confinement, and the Estimated Number of Eggs Produced a Day by Each.

Specimen Number	Date Installed in Cage	Date Cage Discontinued	Total Number of Eggs	Average No. Eggs per Day
A	April 9.....	April 30.....	22	1.04
B	April 13.....	April 29.....	15	.19
C	April 13.....	May 25.....	44	1.04
D	April 26.....	May 26.....	40	1.30
E	June 11.....	December 31..	40	.20
F	June 22.....	July 23.....	35	1.60
G	August 22.....	February 6....	42	.22
H	September 5...	September 19..	24	1.78
I	November 28.	July 8.....	10	.04
J	November 28.	May 1.....	5	.03
K	December 11..	April 17.....	16	1.12
L	December 11..	July 28.....	19	.08

14th of May. These eggs failed to hatch since the workers died before the eggs had an opportunity to develop. Whether more than one worker was laying is not known.

The most complete record is that of Cage 9 in which seventeen workers were confined on May 6th. Between this date and May 19th they laid a total of forty-five eggs. On May 31st small larvæ were observed for the first time and on July 10th a prepupa appeared, which was almost immediately destroyed by the ants before it had a chance to pupate. July 13th another prepupa appeared which met a similar fate. Judging from the size of the prepupæ the writer feels that if these had been allowed to pass into the pupal and adult stages they would have formed workers. Although this is somewhat contrary to general expectation it is by no means impossible or

improbable, for Tanner and Reichenbach, experimenting with other species of ants, have succeeded in rearing worker ants from worker eggs. The writer believes that the workers of *Tapinoma sessile* Say and other ants lay eggs more frequently than is usually supposed and that the eggs may at times develop into castes other than males.

A number of writers contend that when workers lay eggs, the brood developing from these eggs take longer to reach maturity than the brood reared from female eggs. From the present data it would appear that their contention is correct. With some of the eggs just mentioned the incubation period was twenty-three days, and the larval stage forty-one to forty-two days. If three days be allowed the brood for the prepupal, and fourteen days for the pupal stage (the time required by the brood reared from female eggs) then it would have taken the workers from eighty-one to eighty-two days to attain maturity, or a period of eleven to twelve weeks as compared with five to nine weeks for workers produced from female eggs.

Superficially the eggs of the workers appeared larger and more elongate than those laid by the females, but the writer cannot be sure of this statement for he did not measure or otherwise carefully study the eggs, due to their scarcity and the fact that he was anxious to have them incubate successfully.

NESTING SITES.

Probably no ant surpasses the odorous house ant in the diversity of its nesting sites. These ants nest in the soil beneath stones, boards, leaves, or other rubbish; under the bark of rotten logs and stumps; and also in cavities in the stems of elder (probably those made by the caterpillar, *Achatodes zeæ* Harris). Sturtevant found the odorous house ant nesting in the galls made by the wasp, *Amphibolips confluens* Harris that were lying on the ground beneath an oak tree. Essig stated in a letter that the ants nest in bird's nests, rubbish, and trees. In addition the writer has found them nesting in houses in Urbana, Illinois. The type of soil or the altitude has apparently little to do with the choice of their nesting sites. The ants have been found to nest all the way from sea level to heights of over 10,000 feet, and from nests located in boggy or swampy localities to sandy areas along the sea coast or to higher and drier locations inland. A study of the nesting sites

of this species has revealed two facts: (1) their lack of permanency; and (2) their shallowness. Some of the nests are located at the surface of the soil or only slightly beneath it. The nests are most commonly found in the soil beneath stones, rubbish, boards or any such refuse.

RELATION TO CLIMATIC CONDITIONS.

The odorous house ant is evidently acclimated to a wide range of temperature and humidity, since it is distributed from Canada to Mexico. At Urbana, Illinois, the workers have not been noted foraging outdoors at a temperature below 50 degrees Fahrenheit. At this temperature the ants appeared as if numbed by the cold and moved at a slow gait, as compared with their usually quick method of scurrying along. Workers however, have been observed to enter refrigerators and get into the ice compartments where the temperature must certainly have been below 50 degrees Fahrenheit. The ants do not like to cross water and if possible avoid doing so; but once in the water, due to the lightness of their bodies, they can float on the surface film, and in their violent struggles usually manage to propel themselves to one side and crawl out. Many colonies have escaped from the writer by crossing a slow stream of water which surrounded their nest. Rain, by washing their favorite food, honey-dew, from the foliage of plants, often causes the ants to invade homes; in fact, many housekeepers state that the ants are worst immediately after a rain. The writer has seen workers foraging in his yard when a wind storm was in progress, which was so violent as to blow aphids from trees. The aphids referred to were the box elder louse, *Periphyllus negundinis* Thos. That the ants can stand considerable heat is shown by the fact that they often construct nests under small piles of leaves or in compost heaps where the temperature is undoubtedly very high.

RELATION TO OTHER ORGANISMS.

RELATION TO HONEY-DEW EXCRETING FORMS.

Few ants excel the odorous house ant in its honey-dew loving habits. It is an aphidicolous and coccidicolous species par excellence and deserves to be ranked with such ants as the corn field ant, *Lasius niger*. var. *americanus* Emery, the honey

ant, *Prenolepis imparis* Say, and other such honey-dew loving species.

The writer has very commonly witnessed the workers of this species stroking with their antennæ, the box elder louse and obtaining from them the much sought honey-dew. The ants also showed a keen interest in mealy-bugs, especially individuals of the species *Pseudococcus maritimus* Ehrh. which they attempted to pick up and carry away when the writer sought to take specimens of the mealy bugs from the trunk of box elder trees. The workers of the odorous house ant may also distribute plant lice and other honey-dew excreting forms. On two occasions they have been seen carrying live box elder lice in their mouths and also a species of *Macrosiphum*, common on raspberry. A list of some of the insects with which this ant has been found associated is given below:

Aphididæ: Periphyllus negundinis Thos. on box elder; *Chaitophorus viminalis* Monell on American aspen and quaking aspen trees; *Aphis viburnicola* Gill. on *Viburnum opulus* L.; *Aphis* sp. on Englemanns Ivy; *Anuraphis cardui* Linn. on plum; *Aphis* sp. on burdock; *Aphis rumicis* Linn. on *Viburnum opulus* L.; *Aphis helianthi* Monell on sunflower; *Neothomasia populicola* (Thos.) on cottonwood; *Myzus cerasi* on cherry; *Macrosiphum solanifollia* Ashm. on rose and raspberry; *Aphis pseudobrassicæ* Davis on turnips and *Chaitophorus delicata* Walker on an undetermined host.

Coccidæ:—Lecanium sp. on box elder; *Kermes* sp. on water oak; *Chionaspis furfura* (Fitch) on apple; *Saissetia hemisphærica* (Targ.) on lemon and olive; *Coccus hesperidum* Linn. on orange; *Pseudococcus citri* (Risso) on Dracæena plant, the rice paper plant, lemon and coleus; and *Pseudococcus maritimus* (Ehrh.) on box elder.

Membracidæ:—Entylia sinuata Fabr. on sunflower.

RELATION TO OTHER ANTS.

During the period of two years devoted to the study of this ant, the writer failed to observe any fight or animosity on the part of *Tapinoma sessile* Say toward any other native species which it encountered. The odorous house ant is extremely common at Urbana, Illinois, and its nests are situated near those of other species, yet the ants do not seem to fight. When the odorous house ant encounters another species, each

seems to sense the other's presence and they therefore avoid one another. On one occasion the odorous house ant and the corn field ant, *Lasius niger* var. *americanus* Emery, were found foraging in a kitchen at the same time, yet the two species did not intermingle. The tiny thief ant, *Solenopsis molesta* Say, and the ant, *Strumigenys pulchella* Emery, have been found to live with this ant in what appeared to be compound nests. The tiny thief ant is known to feed on the brood of other species of ants and the species of *Strumigenys* are suspected of the same habit.

King (1897) has found mixed colonies of the odorous house ant and the following species: *Formica fusca* var. *subsericea* Say, *Lasius flavus* subsp. *nearcticus* Wheeler, and *Lasius niger*. var. *americanus* Emery.

Woodworth (1910) appears to be the only observer who has seen the odorous house ant in conflict with another species; namely, the ubiquitous Argentine ant, *Iridomyrmex humilis* Mayr. The latter species is noted for its pugnacity toward all ants it encounters except a few small species such as the tiny black ant, *Monomorium minimum* Buckley, and Pharaoh's ant, *Monomorium pharaonis* Linn. Woodworth has the following to say concerning the conflicts between the Argentine ant and the odorous house ant: "This odor is produced by a liquid secretion (speaking of the ejections from the anal glands) which can be ejected from the abdomen as an appreciable drop, and which is used in its contest with the Argentine species. As long as the supply of the secretion lasts the *Tapinoma* has no difficulty in keeping the Argentine ant off, but after having put four or five Argentines out of the combat in this way finally the *Tapinoma* is put to rout and the Argentines are invariably victorious, because they always attack in sufficient numbers. We have observed many battles between these species and the *Tapinoma* is always driven away from its feeding ground and its home despoiled."

If there is any animosity exhibited by individuals of one colony of *Tapinoma sessile* Say towards those of another colony, the writer has not witnessed it. He has mixed colonies artificially in the laboratory and has also seen alien colonies combine of their own accord.

Wheeler (1916) described a species of ant, *Bothriomyrmex dimmocki*, from Massachusetts, which he states may be a

temporary parasite on the odorous house ant, like its cogener, *B. atlantis* Forel, of Tunis is on *Tapinoma nigerrimum* Nyl. The female of *B. atlantis* Forel after descending from her nuptial flight is pulled into the nest of *T. nigerrimum* Nyl., by the workers of that species. She soon crawls on the back of the *nigerrimum* female and decapitates her. After the death of the *nigerrimum* female, the workers of that species accept the *B. atlantis* female and rear the brood she produces. Eventually all the *nigerrimum* workers die and the colony then becomes a pure one of *B. atlantis*.

RELATION TO MYRMECOPHILES AND OTHER NEST INMATES.

In the nests of the odorous house ant, Mann (1911) has found the little cricket, *Myrmecophila oregonensis* Bruner, and also a little wingless wasp, *Isobrachium myrmecophilum* Ashm. "Ashmead states that the genus (*Isobrachium*) is parasitic upon the ants or other myrmecophilous *Coleoptera*," according to Mann who writes further, "the latter being so rare in the nests of *Tapinoma*, it is probable that *Isobrachium* is a parasite on the ant itself." The crickets, *M. manni* Schimmer and *nebracensis* Lugger, have also been taken in the nests of this ant.

The following species of *Coleoptera*, most of which are rove beetles (*Staphylinidæ*), have also been taken from the nests of the odorous house ant by Mann, Wheeler, and others: *Zyras tapinomatis* Mann, *Myrmoecia lugubris* Casey, *Nototaphra lauta* Casey, *Connophron longipenne* Casey, and *Myrmedonia* sp.

The writer has found in the nests of the odorous house ant an unidentified species of spring tail (Collembola), termites (Isoptera), and sow bugs, *Armadillidium* vulgare (Latr.). In the laboratory a species of book lice thought to be *Troctes divinatoria* (Muller) appeared in the cages and fed on the dead bodies of the ants and other refuse. Neither were the ants observed to attack the lice nor the lice to trouble the ants.

RELATION TO PREDATORS.

The only animals known to feed on the odorous house ants are birds and toads. A winged male of this ant was taken from the stomach of a toad, *Bufo* sp., at Anna, Illinois, by a member of the Illinois State Natural History Survey. The following list of the species of birds known to feed on the

odorous house ant was sent to the writer by the United States Bureau of Biological Survey: the pigeon hawk, *Falco columbarius* Linn; the American magpie, *Pica pica hudsonia* (Sabine); the Bartramian sandpiper, *Bartramia longicauda* Bechet; the chimney swift, *Chaetura pelagica* Linn.; the crow, *Corvus brachyrhynchos brachyrhynchos* Brehm; and the red shafted flicker, *Colaptes cafer collaris* (Vigors). Bryant (1914) mentions that the western meadowlark, *Sturnella neglecta neglecta* Audubon, feeds on this species of ant and the writer has observed the English sparrow, *Passus domesticus* Linn. doing the same thing.

RELATION TO PLANTS.

The odorous house ant not only visits plants for the purpose of attending insects but for the purpose of visiting also the floral and extrafloral nectaries and other glandular excretions. The workers have very commonly been seen lapping up exudates on the buds of peonies. This habit apparently causes the buds to dry out to such an extent that the flowers developing therefrom are smaller and in many cases malformed. Dietz (1926) states that the black lawn ant, *Formica fusca* var. *subsericea* Say, can spread peony bud wilt by means of the workers crawling from infected to non-infected buds, while visiting the buds for the much sought exudates. If this be true in case of the lawn ant, it should also apply for the odorous house ant, for it, like the lawn ant, is a persistent visitor of peony buds. Davis of New York (1922) states that he has seen workers of this species visiting the glands at the base of the leaves of *Populus grandidentata* Michx. The writer has seen this ant in attendance on the glands of castor bean plants.

During 1926 the writer found a fungus, *Laboulbenia formicarium* Thaxter, infecting several species of ants in Urbana, Illinois, namely: *Formica fusca* var. *argentea* Wheeler, *F. neogagates* Emery; *Lasius niger* var. *neoniger* Emery, and *F. pallide fulva schaufussi* var. *incerta* Emery. Although the odorous house ant was present on the same blocks as the species mentioned above, this ant was not found to be infested with the fungus.

In the laboratory, colonies of the odorous house ant were often choked out by luxuriant growths of the bread mold, *Rhizopus nigricans* Ehrh., and a species of *Aspergillus*. These molds arose from foods that were allowed to remain in the

cages too long, thriving best where there was considerable excess moisture. The writer did not find the ants outdoors to be affected by any sort of fungus and he doubts if they ever are.

FOOD.

The food of the odorous house ant under normal conditions is largely honey-dew, supplemented by the flesh of organisms and the juices of fruits. The ants are also very fond of the floral and extrafloral secretions of plants. In the laboratory cages the ants occasionally fed on their brood. It is presumed that under outdoor conditions this seldom, if ever, happens.

When the ants enter houses they are almost omnivorous but seem to show a slight preference for sweets. In a number of homes in Urbana, Illinois, the ants have been known to cut through paraffine in order to reach jelly and preserves in containers. They have been noted to infest the following foods: honey, sugar, preserves, pies, custards, marmalades, cooked and uncooked beef, fish, raw and fried liver, boiled and mashed potatoes, stewed prunes, cheese, milk, ice cream, and ripe fruits.

SIZE OF COLONIES.

The colonies of this ant show a wide variation in size, perhaps due to their age. The smallest colony observed contained only four dealated females and about one hundred workers. The largest colony noted was estimated to contain about ten thousand individuals, including brood and adults. An average colony may be expected to contain between two thousand and five thousand specimens.

One of the most striking characteristics of the colonies of this ant is the unusually large number of dealate females, all of which no doubt take part in reproduction. The females, unlike those of the honey bee, are most amiable toward one another.

From observations that have been made it is believed that the sexed-forms are not produced in any but the older and stronger colonies. Although many nests have been examined sexed-forms have been found only in the larger and more flourishing colonies, which were very probably from four to five years of age (Table 3).

GENERAL HABITS OF THE WORKERS.

The workers of the odorous house ant are strikingly slender and graceful in appearance. When alarmed they run with a rapid, erratic, jerky sort of pace and oftentimes with the caudal end of their abdomen slightly elevated. When a nest is disturbed it is only a few seconds until the ants are running everywhere in a somewhat helter-skelter manner.

The workers are splendid foragers, who seek food by night as well as by day. Very seldom are they seen foraging singly but are ordinarily observed trailing along in a file from their

TABLE III.

The Size of the Colonies and the Types of Castes and Immature Stages in the Nest at Various Periods During the Year.

Date	Total No. Individuals	Males	Dealate Females	Male Pupæ	Female Pupæ	Worker		
						Pupæ	Larvæ	Eggs
Apr. 1–25	104	0	4	0—	0	0	x	0
Apr. 8–26	?	0	x	0	0	0	x	0
Apr. 12–26	?	0	x	0	0	0	x	0
Apr. 25–26	?	0	x	0	0	0	x	x
June 11–25	?	0	15	0	0	x	x	x
June 6–26	?	x	x	x	x	x	x	x
June 27–25	6,000–8,000	x	*x	x	x	x	x	x
Aug. 22–25	3,000–4,000	0	x	0	0	x	x	x
Sept. 5–25	10,000	0	240	0	0	x	x	x
Nov. 10–25	?	0	x	0	0	x	x	x

x—Form present.

* Alate and Dealate Females.

NOTE.—Workers are not mentioned in Table because they are present all the year and comprise the largest percentage of individuals in the nest.

nest to the source of food supply. The ants seldom have to travel over thirty to fifty feet to find food, and for this reason their trails are generally not long. Their foraging activities take them into every conceivable sort of place, such as garbage cans, commodes, dirty linens, pantries, sinks, refrigerators, and other places too numerous to mention. Like their cogeners, the Argentine ants, the odorous house ants are prying little busybodies, eternally poking their antennæ into everything.

FEEDING HABITS OF THE WORKERS.

When hungry the ants eat very greedily. The writer found that a worker will feed from three to five minutes before she seems satisfied. During this time her gaster gradually enlarged until the chitinous segments stood out like small islands between the intersegmental membranes.

Workers have often been observed regurgitating food to the female or to other workers. They also feed their larvæ in this manner but never with solid particles as do some of the primitive ants.

NURSING DUTIES OF THE WORKERS.

The workers are good nurses as well as foragers. Whether there is any particular division of labor among them, the writer does not know, since the individuals are practically all the same size (monomorphic) and indistinguishable. Recently emerged individuals (callows) show considerable interest in the brood and will attempt to pick up the brood and carry it away when the nest is disturbed. The dealated females seem to show little interest in the brood, leaving their care to the workers, when these are present in sufficient numbers. The workers show considerable attention to the female and to the brood, around which they cluster. Since the pupæ of this ant has no cocoon covering it, the assistance of the worker for its removal at emergence is not necessary. The writer has, however, noted a worker removing the meconium from a larva which was preparing to enter the prepupal stage. Workers are continually seen licking the brood, the females, or other workers.

ACKNOWLEDGMENTS.

The writer wishes to express his gratitude to Dr. C. L. Metcalf for his unfailing interest and guidance in the work and in the preparation of this paper. He is also grateful to Dr. W. P. Hayes, Dr. R. D. Glasgow, and Dr. W. V. Balduf for their valuable aid and many helpful suggestions. The writer is also indebted to the United States Bureau of Biological Survey and the Illinois State Natural History Survey for furnishing valuable data, and to Dr. W. E. Britton, Mr. J. R. Horton, and Mr. S. A. Rohwer for the loan of specimens. Mr. P. W. Mason kindly determined the plant lice for the author.

SUMMARY.

1. *Tapinoma sessile* Say, a native North American ant, is of considerable economic importance as a house pest not only in Urbana, Illinois, but in localities in California, Nevada, District of Columbia, Maryland, and Mississippi.

2. The synonymy and a redescription of the species is given in this paper. The immature stages of the ant are also described.

3. The common name, the odorous house ant, is applied to the species for the first time.

4. The ants overwinter outdoors as dealate females, workers, and larvæ. Workers begin foraging as early as March 7th. Egg laying and the uniform development of the brood begins in late April and continues until cold weather in the fall or approximately November 1st. The overwintering larvæ attain maturity in April, having required from six to seven months to attain maturity. From April through June workers can be produced in from five to nine weeks, whereas during the period July through September they require only six to seven weeks to attain maturity. Four to five generations of workers a year are postulated.

5. Alate females were observed at various dates ranging from June 17th to early July. Males appeared from June 10th to July 9th. Only large and strong colonies seem capable of producing sexed-forms. Mating probably takes place both in and outside of the nest.

6. Colonies range from a hundred to ten thousand individuals. The average colony contains from two thousand to five thousand individuals, many of which are dealated females; one colony contained over two hundred dealated females.

7. Some of the workers lay eggs. The brood reared from such eggs attained the prepupal stage before they were eaten by the workers. It is believed that if they had attained maturity the adults would have been workers. Development of brood from worker eggs apparently takes longer than the development of brood from female eggs.

8. The ants show a wide diversity in their nesting habits. Nests have been found in houses; under the bark of logs and stumps; in galls on plants; in stems of plants; under debris; and in the soil.

9. The species is apparently eurythermal in disposition as it is found throughout most of North America from the sands of the seashore to heights of over ten thousand feet and from boggy locations to perfectly dry inland spots. Workers have been seen foraging at temperatures as low as fifty degrees Fahrenheit.

10. The natural food of the ants is honey-dew, supplemented by the flesh of organisms. In houses they feed on fruits, vegetables, meats and sweets, but seem to show a preference for sweets.

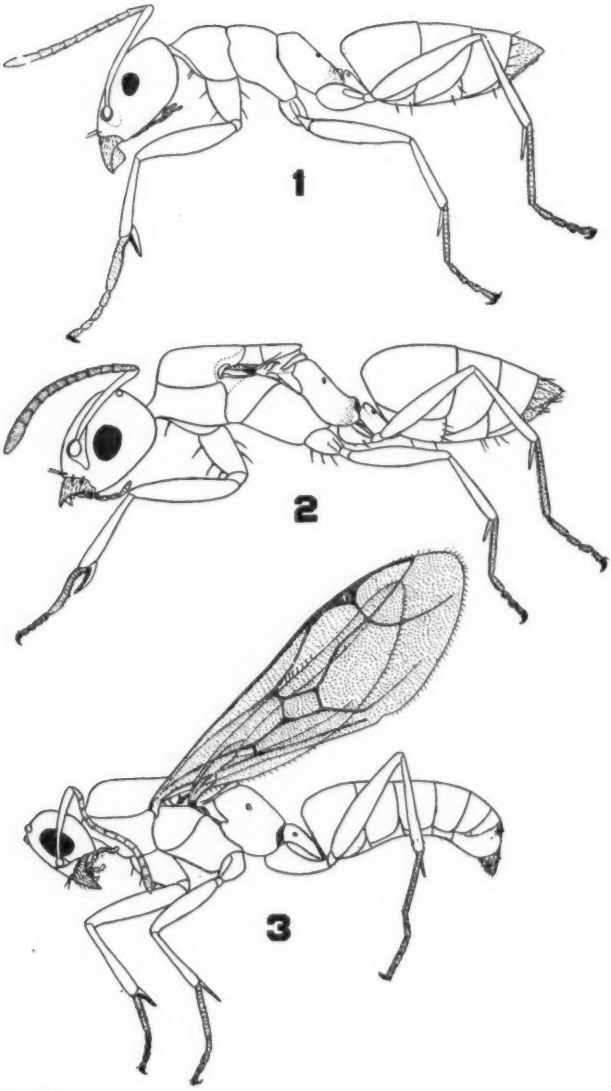
11. A list of the species of plant lice, scale insects, mealybugs, tree hopper, etc., which they are known to attend is given in this paper.

12. A number of beetles, wasps, crickets, spring tails, termites, book lice and other insects have been found living in association with the ants.

13. A species of toad and eight species of birds are known to feed on the ants.

BIBLIOGRAPHY.

Bryant, H. C. 1914. Univ. of Cal. Pub. Zool., 11: 21-24.
Davis, W. T. 1922. Bull. Bklyn. Ent. Soc., 17:2.
Dietz, H. F. 1926. Insect Pest Survey, 6: 122-123.
Doten, S. B. 1910. Nev. Agr. Expt. Sta. Bull., 73.5: 43-44.
Emery, C. 1912. Genera Insectorum, 137: 40.
Essig, E. O. 1926. Insects of Western North America. McMillan Co., N. Y., pp. 863-864.
King, G. B. 1896. Entomological News, 7: 169.
Mann, W. M. 1911. Psyche, 18: 29.
Reichenbach, H. 1902. Biol. Centrabl., 22: 461-465.
Say, Thos. 1836. Boston Jour. Nat. Hist., 1: 287.
Tanner, J. E. 1892. Trinidad Field Naturalist's Club, 1: 123-127.
Wheeler, W. M. 1910. Ants, Their Structure, Development and Behaviour. Columbia Univ. Press, N. Y., pp. 45.
1913. Bull. Mus. Comp. Zool., Harvard, 54: 497.
1915. Bull. Amer. Mus. Nat. Hist., 34: 417-418.
Woodworth, C. W. 1919. Univ. Cal. Publ., 207: 70-71.



Marion R. Smith

Tapinoma sessile Say.

Fig. 1. Worker, greatly enlarged.
Fig. 2. Dealated female, greatly enlarged.
Fig. 3. Alate male, greatly enlarged.

SARCOPHAGA PALLINERVIS AND RELATED SPECIES IN THE AMERICAS.

DAVID G. HALL,
University of Arkansas.

Ravina was described as a genus in 1863 by Desvoidy (1, p. 434), and had for its outstanding character the course of the frontal bristles, which supposedly diverged but little anteriorly. The type of this genus was the European species *haematodes* Mg. Bottcher in his work on Palearctic Sarcophagidæ (4) included Ravinia as a sub-genus of Sarcophaga. Parker (5), the first American to study Sarcophaga with special reference to the specific value of the male copulatory organs, returned Ravinia to generic rank and included in it several new North American species. Aldrich (6, p. 9) again reduced the genus to sub-generic standing because, as he states, "the character of the frontal row is less developed in the males," and, "there are many species outside the group which show it." Both statements are true, as many specimens examined sufficiently prove. In additional material recently worked over, the course of the frontal bristles range from parallel in some species to strongly divergent in others; all species possessing strikingly similar copulatory organs.

Sarcophaga pallinervis, the commonest North American representative of this group, was described by Thompson (2) in 1868 from Hawaii. Timberlake, in working over the species of Sarcophagidæ of Hawaii in 1917-1918, found but one species in the islands that agreed with Thompson's description, this species supposedly being *Ravinia communis* Parker (5). Timberlake sent specimens to Aldrich, who saw that the species were identical, but has hitherto hesitated to reduce *communis* to synonomy without seeing the type specimens in Europe. He states, however, that there can be little doubt of this. *Sarcophaga ochracea* was described by Aldrich (6, p. 255, Fig. 121) as a variety of *pallinervis* Thom. (*communis* Park.). Mr. C. T. Greene, in his work on larval and pupal characters in diptera, has found the species to be very distinct from *pallinervis* in the immature stages. This raises the name *ochracea* Ald. to specific ranking.

In addition to the species which may be placed in the subgenus Ravinia, I have added to the *pallinervis* group five species sometimes placed in Helicobia. Two of these were described as Ravinia by Parker (5). Townsend (7) later placed these in a new genus, which he called Chaetoravinia. Bottcher (4) disregarded the genus Helicobia which has the first vein hairy. He stated that variations in the number of spines on the first vein had been found in a single species, the number varying from bare to completely setulose. As Kramer (3) said in 1904, "In order to understand the very difficult species of Sarcophagidæ, I have collected a number of pairs in copulation during the past few years. One of these pairs consisted of a male of *S. vulnerata* Sch. and a female of *S. cruentata* Mg., which is to say, a male with setulose first vein and a female with first vein bare. This pair shows that a hairy first vein is not sufficient evidence for the recognition of this species, *obviously because the spines break off easily*. Also, several pairs of *S. dissimilis* were taken, several of which had a setulose first vein and several of which had the first vein bare." Whether these statements influenced European authors in regard to the genus Helicobia is not known. It is common knowledge, however, that species entirely unrelated are at times taken in the field in pseudo copulation.

Students of Sarcophagidæ that have followed Bottcher have also disregarded the hairy first vein as being of more than specific importance. Senior White (8) disregarded the character in his work on Oriental Sarcophagidæ, but in a recent letter (July 12, 1927) stated that he followed Bottcher, Parker, and Villeneuve in the matter. Aldrich, who also agrees with Bottcher, in a letter (1927) stated that his opinion was based on the apparent splitting of well defined groups based on genital similarities (those species with which this paper deals), by the presence of the setulose first vein in several species, and the bare first vein in the remaining species. On the other hand, Johnson and Hardy (9) evidently believe, as do other recent authors (Townsend and Curran) that the character is good.

In all species possessing the setulose first vein recently reared in Arkansas (*quadrisetosa* Coq., 72 specimens; *latisetosa* Parker, 47 specimens; *helicis* Towns., 24 specimens), this character is constant. In long series of specimens collected over all the United States, part of Canada, the West Indies,

Mexico, Central America, and South America, no cases have been observed where, if the first vein should be setulose it was bare, unless the spines had been accidentally removed. In this case, scars could be easily detected. Nevertheless, as can be seen in the figures, all the species here treated are closely allied. They are also quite similar in general chaetotaxy. For this reason, it is believed that the first vein character does not play an important part generically in Sarcophaga. However, if the genus *Helicobia* Coq. is ever generally accepted, these species must be referred to the genus *Chaetoravinia* Towns., for they are distinct from the genotype of *Helicobia* which is *helicis* Towns.

This paper includes descriptions of eight new species. In addition, all species from South America are redescribed and all known North and South American species are included in the key and figures. No descriptions included in Aldrich's Sarcophaga and Allies are repeated. This is based on studies of specimens in the National Museum, in the collection at the University of Arkansas, and in the writer's personal collection. The studies were carried on both at the University of Arkansas, and in Washington. All types of new species are deposited at the National Museum.

The writer is under great obligations to Dr. J. M. Aldrich for many suggestions, made both in person and in correspondence throughout the course of these investigations.

Sub-Family SARCOPHAGINÆ.

Genus **Sarcophaga,** Sub-Genus **Ravinia.**

DESVOIDY. 1863. Dipt. Env. Paris, 2, 434 (*Ravinia*).
BOTTCHER. 1912. Deut. ent. Zeit., p. 708; 1913, Deut. ent. Zeit., p. 306. (*Ravinia* as a subgenus of *Sarcophaga*).
PARKER. 1914. Proc. Bost. Soc. Nat. Hist., Vol. 35, p. 52, (*Ravinia*).
TOWNSEND. 1915. Proc. U. S. Nat. Mus., Vol. 49, p. 408, (*Punasarcophaga*).
ALDRICH. 1916. Sarcophaga and Allies, (*Ravinia* as a subgenus of Sarcophaga).
TOWNSEND. 1917. Proc. Biol. Soc. Wash., Vol. 30. (*Euravinia, Miltoravinia, Trixosarcophaga, Andinoravinia, Chaetoravinia*).

1. First vein setulose*.....15
   First vein bare.....2
2. Three dorsocentrals.....3
   Four dorsocentrals.....5
3. First segment of hypopygium dark, at least basally.....4
   First segment of hypopygium red or yellow, (Mexican species), No. 1 *minuta* n. sp.

*Species with first vein setulose belong to the genus *Chaetoravinia* Townsend, if the genus *Helicobia* is ever accepted.

4. Calypters smoky brown, (Mexican species).....No. 2 *obscuripes* n. sp.
   Calypters white, (Northern U. S. species).....No. 3 *peniculata* Pk.
5. Palpi and legs red or yellow, (Southern U. S.).....No. 4 *floridensis* Ald.
   Palpi and legs black..... 6
6. Front about as wide as one eye..... 7
   Front about half as wide as one eye, narrowed below ocelli.....10
7. Yellow pollinose species, (widespread, U. S.).....No. 5 *planifrons* Ald.
   Gray pollinose species..... 8
8. Outer orbitals present (Colombia).....No. 6 *orbitalis* n. sp.
   Outer orbitals absent..... 9
9. Posterior claspers short, small, (New Mexico).....No. 7 *duplicata* n. sp.
   Posterior claspers long, (widespread, U. S.).....No. 8 *pectinata* Ald.
10. First segment of hypopygium black, (widespread, U. S.).No. 9 *pallinervis* Tns.
    First segment of hypopygium yellow.....11
11. Frontal bristles diverging sometimes rapidly in the last few bristles, last four usually approximate.....13
    Frontal bristles not approximated and diverging but little.....12
12. Penis appearing segmented above two large humps on each side behind, (Chile).....No. 10 *aureopyga* n. sp.
    Penis single segmented, humps behind small, tip blunt, (widespread, Southern U. S.).....No. 11 *ochracea*
13. Posterior clasper small.....14
    Posterior clasper stout, (Panama, Costa Rica).....No. 12 *aurigena* Tns.
14. Distal segment of penis elongate, (Peru).....No. 13 *ollantaytambensis* n. sp.
    Distal segment of penis normal, (Peru).....No. 14 *auromaculata* Tns.
15. Males.....16
    Females.....21
16. Outer verticals present, (North America, widespread)..No. 15 *latisetosa* Pk.
    Outer verticals absent.....17
17. Legs brilliant red, (South American, Peru).....No. 16 *rufipes* Tns.
    Legs black, at most but slightly tinged with red.....18
18. Penis with well developed plates in front.....19
    Penis with undeveloped or unapparent plates.....20
19. Parafrontals and parafacials gray pollinose; plates elongate, standing at right angles to body of penis, (Central American, Jamaica, Colombia).....No. 17 *adamsii* sp. n.
    Parafrontals and parafacials golden pollinose; plates short, placed at 45° angle to body of penis, (North American, widespread), No. 18 *quadrisetosa* Coq.
20. Penis with short globose tip, the plates unapparent, lying close to main stalk, (West Indies, Cuba).....No. 19 *globulus* Ald.
    Penis with elongate globose tip, the plates short, but apparent, anterior acrosticals developed in but one pair, middle tibia with one antero-dorsal bristle, (North American, Texas).....No. 20 *reinhardii* sp. n.
21. Third abdominal segment with well developed median marginals.....23
    Third abdominal segment with weak bristles or oppressed hair.....22
    Third abdominal segment without median marginals, legs red, (South American, Peru).....No. 16 *rufipes* Tns.
22. Anterior acrosticals well developed in three or four pairs, middle tibia with but one antero-dorsal bristle, (West Indies, Cuba).No. 19 *globulus* Ald.
    Anterior acrosticals developed in but one pair, the rest but little larger than adjacent pairs, middle tibia with one antero-dorsal bristle, (North America, Texas).....*reinhardii* nov.
23. Middle femur with two bristles on outer front side.....24
    Middle femur with more than two bristles on outer front side, (North American, widespread).....No. 15 *latisetosa* Pk.
24. Parafrontals and parafacials yellow pollinose, (North American, widespread.....No. 18 *quadrisetosa* Coq.
    Parafrontals and parafacials gray pollinose, (Central American, Jamaica, Colombia).....No. 17 *adamsii* sp. n.

In reared material at hand, approximately seventy-five per cent of the females could be accurately determined by the use of this key.

No. 1. **Sarcophaga minuta** sp. nov.

Male. Front .285 of head (in one specimen); parafrontals and parafacials golden pollinose, former with usual row of minute bristles; frontals slightly divergent, about 8 in number, and reaching to middle of second antennal joint; antennæ, second joint somewhat reddish, third two-and-one-half times second, reaching three-fifths distance to vibrissæ which are normal and at oral margin; palpi and proboscis black, ordinary; bucca one-third eye-height, covered with black hairs, none pale before metacephalic suture; back of head with two rows of black hair; outer verticals undifferentiated.

Thorax gray pollinose, somewhat brownish, with usual 3-5 black stripes; ps dc 3; ant acr 1; stpl 3; prsc 1; scutellum with 2 marginals, 1 subapical, and 0 apical. Abdomen gray pollinose, tessellated, somewhat yellowish on sides, usual three shifting black stripes; first and second segments with laterals only; third with median pair, fourth with marginal row of about 12. Hypopygium yellow; first segment golden pollinose, with row of marginal bristles on hind margin; second segment hairy; forceps hairy at base, yellow, black at tip, and essentially like *pallinervis;* accessory plate yellow, short, hairy; posterior clasper quite long, black, with sharp tooth at tip, anterior margin indented; anterior clasper yellowish, long, pointing forward for over two-thirds its length; penis elongated, and on the *pectinata* type.

Legs black; middle femur with comb; middle tibia with two anterodorsal bristles; hind tibia bare. Wings subhyaline; epaulets yellow; costal spine absent; third costal segment about as long as fifth; first vein bare, third with a few hairs; calypters yellowish white.

Female. Front .409 of head; chaetotaxy identical to that in male, with the usual female differences; genital segments of typical *pallinervis* type.

Two specimens (type and allotype) taken by E. G. Smyth on May 29, 1922, at Puebla, Mexico, both from the U. S. Nat. Mus.

Holotype and allotype—In the U. S. N. M.

This species is nearest to *peniculata*, but may be separated by the lack of outer verticals, which are fairly long in *peniculata*.

No. 2. **Sarcophaga obscuripes** sp. nov.

Male. Front .243 of head; parafrontals and parafacials yellowish gray pollinose, the former with usual row of minute hairs; frontals about 9, most anterior one slightly divergent; antennæ reddish black, third joint two times second, reaching three-fifths distance to vibrissæ which are normal and at oral margin; arista plumose three-fifths of length; palpi and proboscis black, ordinary; bucca one-fourth eye-height, covered with black hairs mingling with a few pale ones before metacephalic suture; back of head with two rows of post-ocular cilia; outer verticals absent.

Thorax gray pollinose, with usual three to five black stripes; ps dc 3; ant acr 1 large; stpl 3; prsc 1; scutellum with 2 marginals, 1 subapical, and 0 apical. Abdomen gray pollinose, tessellated, with three shifting black stripes; first and second abdominal segment with laterals only; third with median pair; fourth with marginal row of approximately 12. Fifth sternite composed of two short black arms, unobtrusive, almost obscured, covered with minute short black bristles. Hypopygium red; first segment blackish with a few marginal bristles; second segment with a number of scattered bristles; forceps hairy, red at base, wide behind; accessory plate yellow, short, hairy; posterior clasper black, rather long, thick, with sharp apical tooth; anterior clasper yellow, long, pointing anteriorly for more than four-fifths its length; penis of general *pallinervis* type. Legs black; middle femora with comb; middle tibia with one anterodorsal bristle; hind tibia bare. Wings subhyaline; epaulets yellow; no costal spine; third costal segment shorter than fifth; first vein bare, third with few hairs.

Female. Front .330 of head (in one specimen). Chaetotaxy identical to that of male, except the usual female differences. Genitalia reddish black and of the *peniculata* type. Legs rather reddish.

One male and one female taken at Sierra Madre, Chihi, Mexico, the former September 5, the latter August 24, by Dr. C. H. T. Townsend. The other male is from Mound Valley, Chihi, Mexico, August 22, 1909, presumably by the same collector.

Holotype and allotype—In the U. S. N. M.

No. 3. **Sarcophaga peniculata** Pk.

PARKER. Proc. Bost. Soc. Nat. Hist. XXXV, 58, Pl. VII, Fig. 44, 1914, (Ravinia), male only.
ALDRICH. Sarcophaga and Allies, p. 121, Fig. 49, 1916, (Sarcophaga).
GREENE. Proc. U. S. N. M., LXVI, Art. 29, p. 21, Fig. 39, 1925 (Ravinia), pupa.

Ample material shows that this species is quite common in the northern part of the United States. In addition to the localities mentioned by Parker and Aldrich, specimens are on hand from Ohio, Michigan, Indiana, Oregon, Utah and Arkansas.

Holotype.—Male, in Massachusetts Agricultural College.

No. 4. **Sarcophaga floridensis** Ald.

ALDRICH. Sarcophaga and Allies, p. 249, Fig. 117, 1916.

The red legs of this species make its recognition quite easy. The female can be mistaken only for *S. assidua* Walk., from which it can be immediately separated by the rounded appearance of the genital segments, contrasting to the triangular segments of *assidua*.

It has been collected in Florida, Georgia, Arkansas, and New Mexico.

Holotype and allotype.—Male and female, No. 20557, U. S. N. M.

No. 5. **Sarcophaga planifrons** Ald.

ALDRICH. Sarcophaga and Allies, p. 249, Fig. 118, 1916.
TOWNSEND. Proc. Biol. Soc. Wash., XXX, 1917, (Miltoravinia).

Females of this species may be easily recognized from others of the *pallinervis* group by the presence of but three posterior dorso-centrals in *planifrons*, and four in most of the others. It may be separated from *pectinata*, with which it seems to be most easily confused, by its general golden pollinosity.

The species is generally distributed, for specimens have been determined from Ohio, Kansas, South Dakota, Arkansas, Utah and New Mexico. It has also been reported from Oregon, British Columbia, Saskatchewan, and Texas.

Holotype and allotype.—Male and female, No. 20558, U. S. N. M.

No. 6. **Sarcophaga orbitalis** n. sp.

Male. Front .360 of head (in single specimen); parafrontals and parafacials silvery gray pollinose, the latter with usual row of minute hairs below near eye; frontal stripe broad, almost as wide as one eye; frontal bristles about 8, not divergent below; orbitals distinct; outer verticals present; fronto-orbitals present; antennæ black, third joint three times second, reaching almost to vibrissæ which are normal and at oral margin; arista long plumose for about half its length; palpi and proboscis black, ordinary; bucca one-third eye-height with only black hair before metacephalic suture; back of head with two rows of post-ocular cilia; a few pale hairs below and around middle.

Thorax gray pollinose, with usual 3-5 black stripes; ps dc 4; ant acr 2 distinct; stpl 3; prsc 1; scutellum with 2 marginals, 1 preapical, and 0 apical. Abdomen strongly tessellated, with three shifting black stripes; first and second segments with lateral bristles only; third with median marginal pair; fourth with a marginal row of about 12; fifth sternite so obscured that neither a description nor a drawing can be made of it. Hypopygium red; first segment dark gray pollinose; hind margin with about five bristles, second segment with a number of hairs, somewhat elongated; forceps hairy at base, yellowish except at tips, and of usual *pallinervis* shape; accessory plate small, yellow; posterior clasper short, stout, black, hooked forward at tip; anterior clasper long, yellow, two margins parallel more than half the length

of the clasper, then curving sharply forward into a narrow sharp prolongation; penis dark, narrow at base, single segmented, globose at tip, with usual two plates in front, attached obliquely forward. Legs black; middle femur with comb; middle tibia with one anterodorsal bristle; hind tibia bare. Wings hyaline; no costal spine; epaulets yellow; third costal segment about as long as fifth; first vein bare; third with several hairs.

One male specimen in the National Museum from Paonia, Colombia, Central America, collected by G. E. Quinter.

The specimen agrees in most respects to the *pectinata, planifrons* group. The presence of fronto-orbitals is unusual in male Sarcophagidæ, however, and this character renders the species easily determinable.

Holotype.—In the U. S. N. M.

No. 7. **Sarcophaga duplicata** n. sp.

Male. Front .363 of head (in one specimen); parafrontals and parafacials silvery gray pollinose; former tinged with yellow; latter with usual row of minute hairs below near eye; frontal stripe wide, blackish; frontal bristles about 8, not divergent below; orbitals distinct; outer verticals present; antennæ black, third joint two-and-one-half times second, reaching three-fifths distance to vibrissæ, which are normal and at oral margin; arista plumose for two-thirds its length; palpi and proboscis black, ordinary; bucca one-third eye-height; but black hair before the metacephalic suture; back of head with two rows of postocular cilia, around middle and below with lighter colored hair.

Thorax gray pollinose with usual 3-5 black stripes; ps dc 4; ant acr 2; prsc 1; stpl 3; scutellum with 2 marginals, 1 preapical, and 0 apical. Abdomen gray pollinose with one black stripe, the outer stripes more or less broken up into irregular spots; tessellated; first and second segments with lateral bristles only; third with median marginal pair; fourth with marginal row of approximately 12. Hypopygium red; first segment black with approximately eight marginal bristles; second segment dark red with scattered bristles; forceps black at tip, red at base, slightly divergent when viewed from rear; numerous hairs behind; accessory plate small, reddish; posterior clasper small, black, with sharp curved tip; anterior clasper blackish, curved gently forward, rather long; penis about as in *pectinata*. Wings hyaline; epaulets yellow; no costal spine; first vein bare, third hairy about half way to cross-vein; third costal segment shorter than fifth. Legs black; middle femur with comb; middle tibia with one anterodorsal bristle; hind tibia bare.

One male specimen, State College, New Mexico, collected in 1927 by Fred M. Hull, and given to the author.

Holotype.—Deposited in the U. S. N. M.

No. 8. **Sarcophaga pectinata** Ald.

ALDRICH. Sarcophaga and Allies, p. 251, Fig. 119, 1916.

Sarcophaga pectinata is more common in the southern part of the United States than in the northern. However, several specimens have been taken in Ohio, and one in Indiana. It is listed from Louisiana, Georgia, Alabama, and Arizona, by Aldrich; and Reinhard lists it from Texas. Six specimens have been taken in Arkansas (Hall). Three specimens were sent to the author from Utah (Spalding).

Holotype and allotype.—Male and female, No. 20559, U. S. N. M.

No. 9. **Sarcophaga pallinervis** Thom.

THOMPSON. Eugenies Resa, p. 535, No. 151, 1868.
PARKER. Proc. Bost. Soc. Nat. Hist., XXXV, p. 55, (Figs. on anatomy), (*Ravinia communis*), 1914.
ALDRICH. Sarcophaga and Allies, p. 253, Fig. 120, 1916, (*Sarcophaga communis* Park.).
TOWNSEND. Proc. Biol. Soc. Wash., XXX, p. 191 (Euravinia).
GREENE. Proc. U. S. Nat. Mus., LXVI, Art. 29, p. 7, pl. 1, Fig. 3 (pupa), 1925.

The species is one of the most common Sarcophagids in the northern part of the United States, and has commonly been found breeding as a scavenger. Specimens have been examined from Quebec to Maryland, and from Vancouver to California. It is taken in Ohio from May 3 to October 20, and in Arkansas from March 12 to November 6.

Type.—Probably with Thompson's types of Eugenies Resa at Naturhistoriska Riksmuseets, Stockholm.

No. 10. **Sarcophaga aureopyga** n. sp.

Male. Front .183 of head (in single specimen); parafrontals and parafacials golden pollinose, latter with scattered minute hairs below near eye; frontal stripe blackish, well defined; frontal bristles about 12, slightly divergent below, to middle of second antennal joint; orbitals distinct; outer verticals absent; antennæ black, third joint three times second, reaching four-fifths distance to vibrissæ which are somewhat approximated and above oral margin; arista with medium length plumosity for over half its length; palpi and proboscis black, ordinary; bucca, one-third eye-height; but black hair before suture; back of head with two rows of post-ocular cilia around middle and below with yellowish hairs; lower rear of head slightly bulging, long, totally gray pollinose.

Thorax silvery pollinose, usual 3-5 dense black stripes, intermedian gray stripes brownish when viewed from in front; ps dc 4; ant acr 3.

none large; prsc 1; stpl 3; scutellum with 3 marginals, 1 subapical and 0 apical. Abdomen yellowish gray pollinose, tessellated, with three shifting black stripes; first and second segments with lateral bristles only; third with median pair; fourth with marginal row of about 14. Fifth sternite composed of two long black arms, but slightly divergent near center, convergent at tips, with numerous spines on edges. Hypopygium red; first segment dark, with marginal row of six bristles; second segment red with numerous black bristly hairs; forceps red at base, black at tips, clothed from base almost to tips with black hair, from behind, divergent to tips; accessory plate small, yellow, with a few black hairs; posterior clasper black, long, straight to tip which curves forward to sharp point; anterior clasper long, yellow, curving gently forward to blunt tip, a number of hairs along the outer margin; penis rather short, dark, with the appearance of being composed of two segments, a base which joins to the tip just above the plates in front, first segment stout, short; second segment long, dark, blunted at tip, a hump on each side behind, tip with notch in center behind; the two plates in front divergent, long, black, standing almost at right angles to body of penis; immediately above these, another pair of plates, small, semi-transparent, the tips of which are also divergent. Legs black; middle femur with comb; middle tibia with one anterodorsal bristle; hind tibia bare; both middle and hind tibia somewhat reddish. Wings hyaline; epaulets yellow; first vein bare, third with several hairs; costal spine absent; third costal segment almost equal to fifth and sixth together.

Female unknown.

One specimen from the U. S. Nat. Mus., collected June 8, 1925, at Angol, Chile. (Collector unknown).

Holotype.—In the U. S. N. M.

No. 11. **Sarcophaga ochracea** Ald.

ALDRICH. Sarcophaga and Allies, p. 255, Fig. 121, 1916. (*Sarcophaga communis*, var. *ochracea*).

GREENE. Proc. U. S. Nat. Mus., LXVI, Art. 29, p. 7, pl. 1, Fig. 2, 1926. (Description of pupa).

Although *S. ochracea* was described as a variety of *pallinervis*, Mr. C. T. Greene told me that he had found characters in the immature stages of the two species that satisfactorily and conclusively separated them. The adult males may be separated by the first genital segment being black in *pallinervis*, red in *ochracea*.

Specimens have been commonly collected from Southern Ohio, southward. *Pallinervis* and *ochracea* have been collected in Arkansas in about equal numbers.

Holotype and allotype.—Male and female, No. 20560, U. S. N. M.

No. 12. **Sarcophaga aurigena** Tns.

TOWNSEND. Ann. Ent. Soc. Amer., IV, pp. 129-130, 1911, (*nomen nudum*).
TOWNSEND. Proc. U. S. Nat. Mus., XLIII, No. 1935, pp. 357-358, 1912.
TOWNSEND. Proc. Biol. Soc. Wash., XXX, p. 191, (*Trixosarcophaga*), 1917.

Male. Front .200 of head (average of four—.176, .212, .206, .206); parafrontals and parafacials golden pollinose, latter with usual row of delicate hairs below near eye; frontal stripe blackish, well defined. Frontal bristles about 10, the last four approximated and quite divergent, reaching to the middle of second antennal joint; orbitals distinct; outer verticals absent; antennæ black, third joint reaching two-thirds distance to vibrissæ, which are slightly approximated and above the oral margin; arista long plumose for three-fifths its length; palpi and proboscis black, ordinary; bucca one-third eye-height, covered with black hair; back of head with two rows of postocular cilia and numerous pale hairs around middle and below.

Thorax yellowish gray pollinose with usual 3-5 black stripes, gray stripes appearing golden when viewed from in front; ps dc 4; ant acr several pair; prsc 1; stpl 3; scutellum with 3 marginals, 1 subapical, and 0 apical. Abdomen golden pollinose along sides; usual 3-5 shifting black stripes; first and second segments with laterals only; third with weak median marginal pair, somewhat reddish; fourth reddish with golden pollen, and a marginal row of about fourteen bristles. Hypopygium red; first segment with marginal row of six bristles; forceps reddish with black hair behind, tip black; accessory plate small, reddish; posterior clasper rather stout, curved somewhat forward, blackish; anterior clasper yellow, curving gently forward to blunt tip; penis yellow, rather heavy at tip, blunt, with two plates on anterior edge diverging but slightly. Wings hyaline; epaulets yellow; no costal spine; first vein bare; third costal segment about equal to fifth. Legs black; middle femur with comb; middle tibia with two anterodorsal bristles, hind tibia bare.

Type.—Cat. No. 15201, U. S. N. M. Female, March 29, 1911, T. D. 4024 f. r. s.

Common in Piura, Peru.

Redescribed from a male specimen labelled *Trixosarcophaga aurigena* Tns. by Townsend. The type of *aurigena* Tns. is a female, and just what species it is is a matter of conjecture. The male specimen herein described is from Trinidad River, Panama, collected by August Busck on May 9, 1911. Four other specimens, three males and one female, from Higento, San Mates, Costa Rico (Pablo Schild) 25 VII 17, are probably the same species.

No. 13. **Sarcophaga ollantaytambensis** n. sp.

Male. Front .201 of head (average of 2—.202, .200); parafrontals gray pollinose, tinged with yellow; parafacials golden pollinose, with

usual row of minute hairs below near eye; frontal stripe well defined; blackish, frontal bristles about 9, the last slightly diverging to the middle of second antennal joint; orbitals distinct; outer verticals absent; antennæ blackish; third joint three times second, and reaching three-fourths distance to vibrissæ, which are slightly approximated and above oral margin; arista long plumose for over one-half its length; palpi and proboscis black, ordinary; bucca one-third eye-height, the anterior half golden pollinose with but black hair before the suture; back of head with two rows of post-ocular cilia, a number of light colored hairs near the middle and below.

Thorax silvery gray pollinose, the usual 3-5 black stripes, lateral-dorsal margins of thorax with golden yellow pollen; ps dc 4; ant acr 3 or 4; prsc 1; stpl 3; scutellum with 3 marginals, 1 subapical, 0 apical. Abdomen yellowish gray pollinose, the sides with golden yellow spots; the usual three shifting black stripes; first and second segments with lateral bristles only; third with small median pair, fourth with marginal row of about 16. Fifth sternite in the form of two black arms, not divergent, the edges covered with numerous short black spines. Hypopygium red; first segment blackish with golden pollen, with marginal row of about six bristles; second segment red, with scattered bristles; forceps reddish except the tips, which are black; behind covered with black hair, tips black, sharp; behind, divergent for about half their length; accessory plate yellow, small, with a number of black hairs; posterior clasper blackish, long and straight sharp and curved forward at tip; anterior clasper long, yellow, curving gently forward to blunt tip; penis long, black, tip blunt and very long, plates in front black, divergent "V" like. Legs black; middle femur with comb; middle tibia with one anterodorsal bristle; hind tibia bare. Wings hyaline; epaulets yellow; no costal spine; first vein bare, third with several setæ; third costal segment about equal to fifth.

Female. Front .366 of head (average of 2—.370 and .362); chaetotaxy like that in male, except for usual female differences. Genital segments reddish with golden pollen, rounded, essentially as in *pallinervis*.

Four specimens from the U. S. Nat. Mus. collected by the Yale Peruvian Expedition at Ollantaytambo, Peru (9000 feet). 20 vii, 1911.

Holotype and allotype.—In U. S. N. M.

No. 14. **Sarcophaga auromaculata** Tns.

TOWNSEND. Proc. U. S. N. M., XLVIV, No. 2115, p. 409, (*Punasarcophaga*), 1915.

Male. Front .218 of head (in one specimen); parafrontals and parafacials light golden pollinose, the latter with several rows of bristly hairs below near eye; frontal stripe blackish, well-defined; frontal bristles about 12, moderately diverging below to about middle of second antennal joint; orbitals distinct; outer verticals absent; antennæ brown, third joint twice second, reaching two-thirds distance to vibrissæ,

which are slightly above the oral margin; arista long plumose for over one-half its length; palpi and proboscis black, ordinary; bucca one-third eye-height, with anterior golden spot, covered with black hair; back of head with three rows of post-ocular cilia and numerous light colored hairs around middle and below.

Thorax yellowish gray pollinose, usual 3-5 black stripes, sides quite brilliantly yellow pollinose; ps dc 4; ant acr 2-3; prsc 1; stpl 3; scutellum with 3 marginals, 1 subapical, 0 apical. Abdomen yellowish gray pollinose, tessellated, usual three shifting black stripes; sides and fourth segment covered with golden pollen; first and second segments with laterals only, third with weak median marginal pair, fourth with marginal row of about 16. Fifth sternite blackish, composed of two blackish arms slightly divergent, covered with minute black spines on inside edges. Hypopygium golden yellow pollinose; first segment yellow with marginal row of about six bristles; second segment with a number of scattered bristles; forceps red at base, black tips, covered with black hair behind, divergent when viewed from rear; accessory plate small, yellow, with blackish hair; posterior clasper rather long, small, pointed forward at tip; anterior clasper yellow, curving gently forward to blunt tip; penis long, rounded rather forward, rounded at tip; plates on front edge dark, rather divergent. Wings hyaline; epaulets yellow; no costal spine; first vein bare; third costal segment about as long as fifth and sixth together. Legs black, tibiæ somewhat reddish, middle femur with comb, middle tibia with two anterodorsal bristles, hind tibiæ bare. Length 7 to 9 mm.

Townsend had six males (the type series) from Aroya, Peru, over 12,000 feet, Rio Mantaro Valley bottom, March 7, 1913 (Townsend).

Redescribed from one male taken at Huadquinia, Peru, July 26, 1911, by the Yale Peruvian Expedition.

Holotype.—Cat. No. 19431, U. S. N. M.

No. 15. **Sarcophaga latisetosa** Pk.

PARKER. Proc. Bost. Soc. Nat. Hist., XXXV, p. 63, pl. IV, Fig. 26; VII, Fig. 46, (*Ravinia*), 1914.

ALDRICH. Sarcophaga and Allies, p. 299, Fig. 144, (*Sarcophaga*), 1916.

The males of *S. quadrisetosa* and *latisetosa* may be separated most easily by the longer posterior clasper of *latisetosa*. The anterior clasper of *latisetosa* is of about the same width throughout, which contrasts strongly with the anterior clasper of *quadrisetosa*, which is quite wide at the middle and pointed at the tip. In reared material, about seventy-five per cent of the females of *latisetosa* and *quadrisetosa* were separated by the character given in the key.

This species is very common in the northern part of the United States, and is taken in fewer numbers south. A few

specimens have been taken in Arkansas, and Aldrich mentions a specimen from Florida in Sarcophaga and Allies.

Holotype.—In collection of Massachusetts Agricultural College.

No. 16. **Sarcophaga rufipes** Tns.

TOWNSEND. Proc. Biol. Soc. Wash., XXX, p. 190, 1917, (*Andinoravinia*).

The genus Andinoravinia Tns., based on the sole species *rufipes*, is very closely related on genital similarities to those species presented in this paper. It seems to the author that the species belongs here, not only on genital similarities, but on chaetotaxy.

Male. Front .266 of head (average of 3—.240, .202, .238); parafrontals and parafacials brilliant golden pollinose, latter with minute row of hairs below, near eye; frontal stripe black, well-defined; frontal bristles approximately seven, the last divergent, reaching to middle of second antennal joint; orbitals distinct; outer verticals absent; antennæ reddish, third joint twice second, reaching three-fourths distance to vibrissæ, which are normal and at oral margin; arista long plumose for half its length; palpi yellow; proboscis brown, both ordinary; bucca two-fifths eye-height with black hair, none pale before suture; back of head with two rows of black hairs, a few pale ones in middle and below.

Thorax yellowish gray pollinose with usual 3-5 black stripes, which are golden when viewed from front; ps dc 4; ant acr well developed in one pair; prsc 1, small; scutellum with 2 marginals, 1 subapical and 0 apical. Abdomen gray pollinose, tessellated, yellow along sides, the usual three shifting black stripes, no median marginals, fourth segment with marginal row of approximately 14. Fifth sternite black on arms, which diverge but slightly; the tips stand out prominently and are clothed with short black hair. Hypopygium yellow; first segment dark anteriorly with marginal row of about eight bristles; second segment globose, yellow, with numerous hairs, a few of which may be called bristles; forceps long, yellow, black at tips, covered with long upcurved hair behind; the tips are quite divergent when viewed from behind; accessory plate small, yellow, triangular with corners rounded; posterior clasper black, rather straight with a well developed apical tooth and emarginate anterior edge; anterior clasper long, yellow, bent forward, about twice length of posterior clasper; penis with single segment, long, yellow, cylindrical, widening rapidly out into a blunted brownish tip in front of which extend two brown transparent plates; situated immediately above is a divided plate; from behind, penis is slender for three-fifths its length, suddenly expanding to twice its former width. Legs bright reddish yellow; outer sides of front femora dark, almost black; all tarsi black; middle femur with comb; middle tibia with two anterodorso bristles; hind tibia bare. Wings hyaline; veins yellowish; epaulets yellow; costal spine minute; third costal segment about equal to fifth; first and third veins setulose.

Female. Front .335 head (average of 4—.360, .336, .327, .320); orbitals distinct; frontal stripe wide; chaetotaxy identical to that of male except an additional pair of anterior achrosticles. Black on posterior tibia less extensive in female than in male; genitalia yellow; sixth sternite somewhat rounded, about as long as wide.

A long series of specimens from Peru, South America, including the type and allotype collected by the Yale Peruvian Expedition during July, 1911, at Ollantaytambo, 9000 feet; Tincochaca, 7000 feet; and Urubamba, 9500 feet; all in the U. S. Nat. Mus.

The brilliant reddish legs separate this species from all others closely related.

Type.—In the U. S. N. M.

No. 17. **Sarcophaga adamsii** n. sp.

Male. Front .194 of head (average of 4—.166, .210, .203; .200); parafrontals and parafacials gray pollinose, the former with usual row of minute hairs below, near eye; orbitals distinct; outer verticals absent; frontal stripe narrow, black; frontal bristles about seven, moderately diverging to middle of second antennal joint; antennæ reddish, third joint three times second, reaching three-fifths distance to vibrissæ, which are normal and at oral margin; palpi and proboscis black, ordinary; arista long plumose for half its length; bucca one-fourth eye-height, with a number of only black hairs; back of head with three rows of post-ocular cilia, a few pale ones below and around middle.

Thorax gray pollinose; the usual three to five black stripes, the intermediate ones distinctly brownish; ps dc 4; ant acr 2; prsc 1; stpl 3; scutellum with 2 marginals, 1 subapical and 0 apical. Abdomen silvery white pollinose, the black stripes not distinct; first and second segments with median marginal pair; fourth with marginal row of about 10. Fifth sternite small, with two very short black arms diverging "U" shaped, the tips curving downward, with but few hairs. Hypopygium red; first segment with several marginal bristles; second segment with a few scattered bristles; forceps reddish at base, black at tips which curve forward, quite hairy behind, viewed from behind, divergent to tips; accessory plate small, yellow; posterior clasper long, dark, curved forward, emarginate on anterior edge; anterior clasper longer than penis, yellow, curved forward to blunt tip; penis of single segment, yellow, basally narrow, widening out toward tip, dark with cut-off appearance; plates on anterior edge dark, standing at right angles to body of penis. Wings hyaline; epaulets yellow; no costal spine; first and third veins hairy; third costal segment as long as fifth. Legs black; middle femur with comb; middle tibia with one anterodorsal bristle; hind tibia bare.

Female. Front .304 of head; chaetotaxy identical to that of male with the usual female differences; genital segments red, silvery pollinose.

Seven specimens: two males, Santa Maria, Colombia, May, 1913 (J. H. Egbert) from the U. S. Nat. Mus.; three pairs

taken in copula, Jamaica; and nine males, Mexico, from the Adams Collection at the University of Arkansas.

Holotype and allotype.—Pair taken in copulation, deposited in U. S. N. M.

No. 18. **Sarcophaga quadrisetosa** Coq.

COQUILLETT. Ent. News, XII, p. 17, (*Helicobia*), 1900.
PARKER. Proc. Bost. Soc. N. H., XXXV, p. IV, Fig. 27, (*Ravinia*), 1914.
ALDRICH. Sarcophaga and Allies, p. 296, Fig. 143, (*Sarcophaga*), 1916.
TOWNSEND. Proc. Biol. Soc. Wash., XXX, (*Chaetoravinia*), 1917.
GREENE. Proc. U. S. Nat. Mus., XLVI, Art. 29, p. 14, Fig. 20, (*Chaetoravinia*), (pupa), 1925.

Specimens of *quadrisetos* have been examined from Ohio, Idaho, Oregon, Utah, Kansas, Arkansas, New Mexico, and Georgia. It is not uncommon throughout the United States, but is seemingly most numerous from the Ohio River, south.

It is commonly reared as a scavenger.

Holotype.—Male No. 5395, U. S. N. M.

No. 19. **Sarcophaga globulus** Ald.

ALDRICH. Sarcophaga and Allies, p. 299, Fig. 145, 1916.

The main character which separates the male of *S. globulus* Ald. from closely allied species, is the rounded apex of the penis and the two transparent plates on the anterior face of the penis which turn backward toward the base. In all specimens of related species examined, no cases have been seen which even approximate this condition, the nearest being S. latisetosa Pk., in which the plates usually assume a 45° angle.

The female of *S. globulus* is separated from the female of *S. reinhardii* by the presence of three or four pairs of anterior achrosticals in *globulus*, but one pair being present in *reinhardii*.

No specimens are known to the author except the type series collected at Havana, Cuba, by Professor C. F. Baker.

Holotype and allotype.—Male and female, No. 20575, U. S. N. M.

No. 20. **Sarcophaga reinhardii** sp. nov.

Male. Front .203 of head (average of 5—.200, .229, .204, .167, .218); parafrontals and parafacials silvery pollinose, tinged with yellow, latter with usual row of delicate hairs below, near eye; frontal stripe well defined, blackish; frontal bristles about 8, moderately divergent below; orbitals distinct; outer verticals absent; antennæ brown, third joint three times second, reaching five-sixths distance to vibrissæ, which are normal and at oral margin; arista long, plumose for one-half its length; palpi and proboscis black, former somewhat longer than usual; bucca one-fifth eye-height, but black hair before the suture; three rows of post-ocular cilia, a number of light-colored hairs near middle and below.

Thorax yellowish gray pollinose, usual three to five black stripes, sub-median gray ones divided by narrow black line to beyond suture; ps dc 4; ant acr developed in 1 pair, rest small; prsc 1; stpl 3; scutellum with 2 marginals; 1 preapical and 0 apical. Abdomen yellowish gray pollinose, tessellated with three not very changeable black stripes; first and second segments with laterals only; third with median pair; fourth with marginal row of approximately fourteen. Fifth sternite black with a curious pad-like tip on each arm, the pad itself covered with numerous spines and small hairs, several of latter long. Hypopygium red; first segment dark basally, gray pollinose; posterior margin with row of 8 bristles; second segment yellowish, with several scattered bristles; forceps long, hairy behind, reddish at base, black at tip, the fore margin emarginate, tip sharp; anterior clasper bent forward at half its length, long, yellow, infuscated at blunt tip; penis apparently of single segment, basal part elongated, cylindrical, bent somewhat forward, shining yellow, beyond middle, expanding into globular tip, on anterior face of which is situated a pair of short transparent plates which curve slightly backward toward base of penis; in rear view tip is indented in center. Legs black, tibia somewhat reddish in several specimens; middle femur with comb; middle tibia with one antero-dorsal bristle; hind tibia bare. Wings hyaline; epaulets yellow; veins somewhat yellow; costal spine absent; third costal segment about as long as fifth; both first and third veins setulose.

Female. Front .346 of head (average of 4—.307, .355, .363, .360); orbitals and outer verticals distinct. Chaetotaxy identical to that in male, except the median marginals on third abdominal segment are suppressed and not distinct; middle femur without comb; genital segments rounded, reddish; sixth sternite longer than wide.

A long series of both sexes collected at College Station, Texas, from the U. S. Nat. Mus., collected by H. J. Reinhard for whom the species is named. The species seems to be common throughout the summer. A series of nine specimens collected in July, 1927, by F. M. Hull and sent to the author. One male, Dividend, Utah, 1927 (Tom Spalding).

Holotype and allotype.—In the U. S. N. M.

BIBLIOGRAPHY.

1. **Desvoidy.** 1863. Dipt. Env. Paris.
2. **Thompson.** 1868. Eugenies Resa, No. 151, p. 535.
3. **Kramer.** 1904. Zeit. fur Syst. Hym. und Dipt., Vol. IV, No. 6, November, p. 347.
4. **Bottcher.** 1912–13. Deut. ent. Zeit. 1912, 525-544 and 705-736; and 1913, 1-16, 115-130, 239-254, 351-377.
5. **Parker.** 1914. Proc. Bost. Soc. Nat. Hist., Vol. 35, 1-77, 8 plates.
6. **Aldrich.** 1916. Sarcophaga and Allies.
7. **Townsend.** 1917. Proc. Ent. Soc. Wash., Vol. 30.
8. **Johnson** and **Hardy.** 1923. Records of the Australian Museum, Vol. XIV, No. 1.
9. **Senior White.** 1924. Records of the Indian Museum, Vol. XXVI, pt. 3, pp. 193-283, pl. VIII-XIX.

EXPLANATION OF PLATES.

PLATE XIX.

Fig. 1.* *Sarcophaga minuta* Hall.
Fig. 2. *Sarcophaga obscuripes* Hall.
Fig. 3. *Sarcophaga peniculata* Parker.
Fig. 4. *Sarcophaga floridensis* Aldrich.
Fig. 5. *Sarcophaga planifrons* Aldrich.

PLATE XX.

Fig. 6. *Sarcophaga orbitalis* Hall.
Fig. 7. *Sarcophaga duplicata* Hall.
Fig. 8. *Sarcophaga pectinata* Aldrich.
Fig. 9–11. *Sarcophaga pallinervis* Thompson.
Fig. 10. *Sarcophaga aureopyga* Hall.

PLATE XXI.

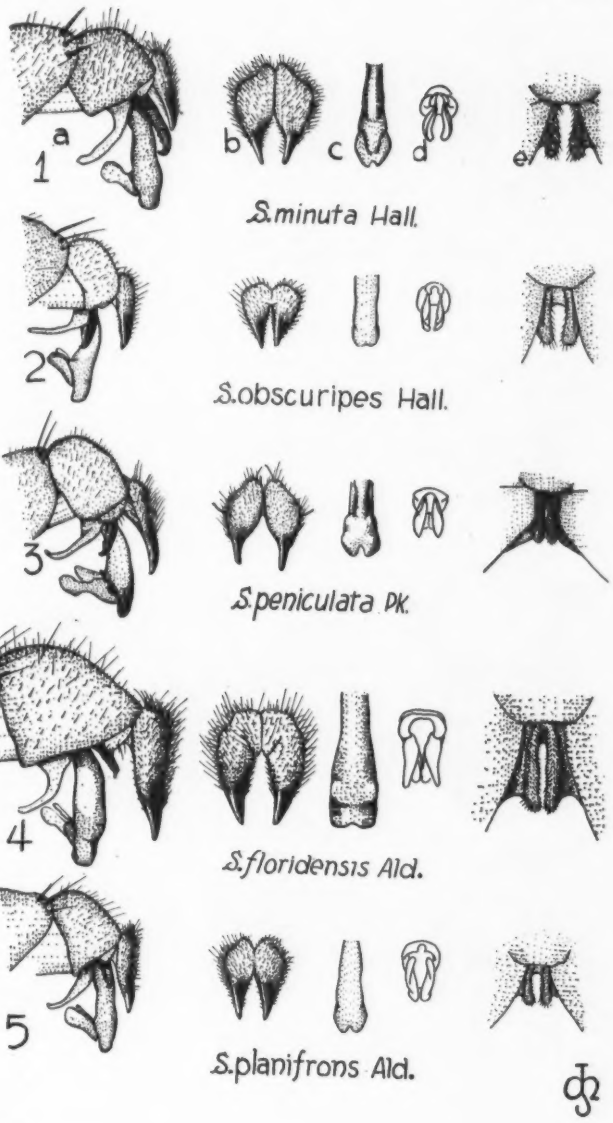
Fig. 12. *Sarcophaga aurigena* Townsend.
Fig. 13. *Sarcophaga ollantaytambensis* Hall.
Fig. 14. *Sarcophaga auromaculata* Townsend.
Fig. 15. *Sarcophaga latisetosa* Parker.

PLATE XXII.

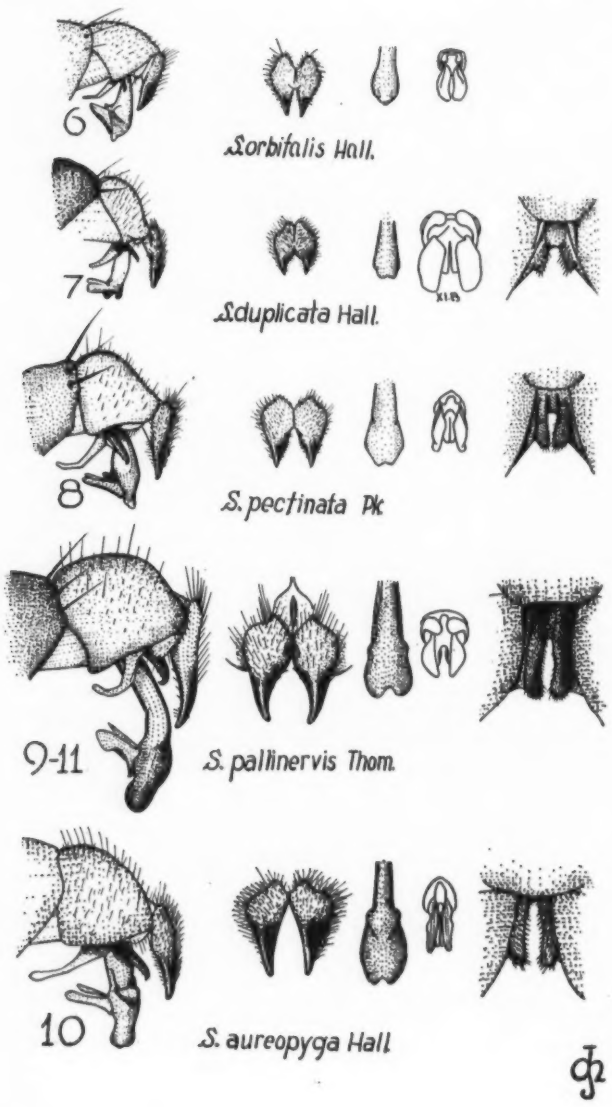
Fig. 16. *Sarcophaga rufipes* Townsend.
Fig. 17. *Sarcophaga adamsii* Hall.
Fig. 18. *Sarcophaga quadrisetosa* Coquillett.
Fig. 19. *Sarcophaga globulus* Aldrich.
Fig. 20. Sarcophaga *reinhardii* Hall.

---

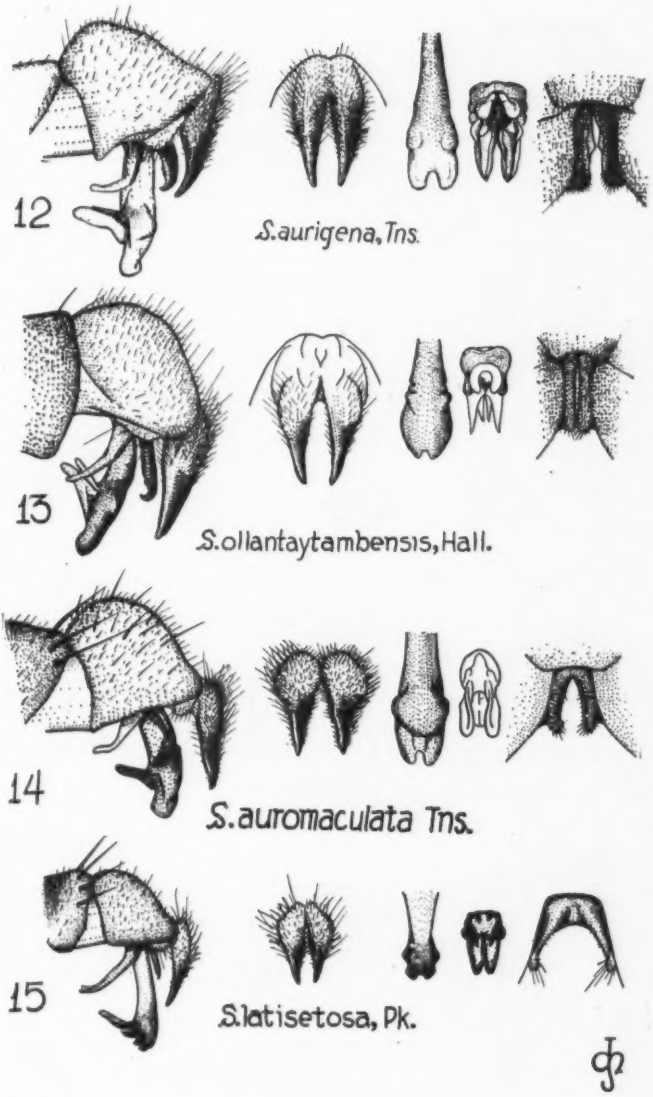
*Each species, with one exception, (orbitalis), has five drawings.
(a) Left lateral view of hypopygial composite.
(b) Rear view of forceps.
(c) Rear view of penis.
(d) Tip of penis.
(e) Fifth sternite.


a
b
c
d
e
1
S. minuta Hall.
2
S. obscuripes Hall.
3
S. peniculata Pk.
4
S. floridensis Ald.
5
S. planifrons Ald.

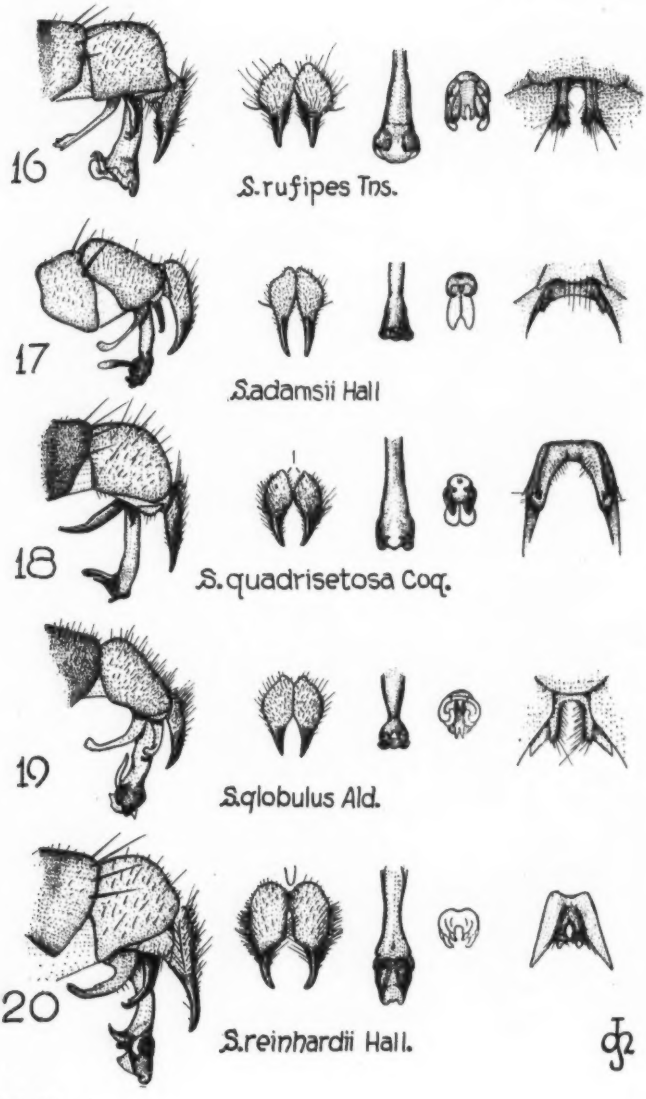
David G. Hall


6
S.orbifalis Hall.
7
S.duplicata Hall.
8
S. pectinata Pk.
9-11
S. pallinervis Thom.
10
S. aureopyga Hall.

David G. Hall


12
S.aurigena, Tns.
13
S.ollantaytambensis, Hall.
14
S.auromaculata Tns.
15
S.latisetosa, Pk.

David G. Hall


16
S. rufipes Tns.
17
S. adamsii Hall
18
S. quadrisetosa Coq.
19
S. globulus Ald.
20
S. reinhardii Hall.
DGH

David G. Hall

MEMBERSHIP LIST

Entomological Society of America

In this list, which is arranged alphabetically, members are given in lower case type, Fellows in small caps and Honorary Fellows in capitals. The year of admission to membership is given before the name, and of election to Fellowship and Honorary Fellowship in parentheses following the address. Names of Life Members are indicated by asterisk (*) and the special field of work in italics. Ch. indicates Charter Member, 1906.

'26. Abbott, Cyril E., 1627 Anderson Ave., Manhattan, Kans. *Behavior.*
'26. Ackerman, Lloyd, Biol. Lab., West. Res. Univ., Cleveland, Ohio. *Physiol.*
'28. Adams, Charles F., Ind. State Bd. Health, Indianapolis, Ind. *Dipt.*
'28. Adkins, T. R., 309 Aztec Bldg., San Antonio, Texas.
'08. Ainslee, C. N., 5009 Orleans Ave., Sioux City, Iowa. *Hymenoptera.*
Ch. *ALDRICH, J. M., National Museum, Washington, D. C. (F. '07). *Dipt.*
'10. ALEXANDER, C. P., Fernald Hall, Mass. Agr. Coll., Amherst, Mass. (F. '20). *Tipulidæ.*
'13. Allee, W. C., Zoology Bldg., Univ. of Chicago, Chicago, Ill. *Behavior.*
'26. Allen, Harry W., Jap. Beetle Lab., Moorestown, New Jersey. *Tachinidæ.*
'26. Andrews, Arthur W., 133 Tyler Ave., Detroit, Mich. *Coleop.*
'23. Armstrong, Thomas, Ent. Lab., Vineland Station, Ontario, Canada. *Scarabaeidæ.*
'22. Arnold, George F., State Plant Board, A. & M. Coll., Miss. *Cerambycidæ.*
'26. Atkinson, Norman J., Vivarium Bldg., Champaign, Ill. *Noctuidæ.*

'18. Babcock, O. G., Box 407, Sonora, Texas. *Mallophaga, Anoplura.*
'26. Babiy, Paul P., Dept. of Ent., Cornell Univ., Ithaca, N. Y. *Bombidæ.*
'22. Baerg, W. J., Univ. Ark., Fayetteville, Ark. *Poisonous Arthropods.*
'19. Baird, A. B., Ent. Branch, Dept. Agr., Ottawa, Canada. *Parasitic Hymenop.*
'11. Baker, A. C., Bureau of Ent., Dept. Agr., Wash., D. C. *Aphididæ* and *Aleyrodidæ.*
'12. Baker, A. W., Ont. Agr. Coll., Guelph, Ontario. *Mallophaga, Coleoptera.*
'22. Baker, Howard, 2303 W. Douglas Ave., Wichita, Kans. *Codling Moth.*
'28. Baker, W. L., Dept. Zool., Univ. of Minn., Minneapolis, Minn.
'19. Balduf, W. V., 308 Old Law Bldg., Univ. Ill., Urbana, Ill. *Eurytomidæ* (*Chalcidoidea*).
Ch. *BALL, E. D., Ent. Lab., Sanford, Fla. (F. '08). *Jassidæ, Cercopidæ, Membracidæ, Fulgoridæ.*
'26. Ballou, Charles A., Jr., 64 Sagamore Road, Bronxville, N. Y. *Coleop.*
'22. Banghart, Joseph, 934 Hollister St., Olney, Ill. *Lepidop., Coleopt.*
Ch. Banks, Charles S., 1411 Leveriza, Malate, Manila, P. I. *Dipt., Hemipt.*
'08. BANKS, NATHAN, Mus. Comp. Zool., Cambridge, Mass. (F. '14).
Ch. Barber, H. G., 143 E. Third Ave., Roselle, New Jersey. *Hemipt., Heterop.*
Ch. Barber, H. S., U. S. Nat. Mus., Washington, D. C. *Lampyridæ.*
'23. Bare, Clarence O., P. O. Box 1525, Sanford, Fla. *Notonectidæ.*
Ch. Barlow, John, State College, Kingston, Rhode Island.
'27. Barnes, Horace Francis, Rothamsted Exp. Sta., Harpenden, Herts, England.
Ch. BARNES, WM., 320 Millikin Bldg., Decatur, Ill. (F. '13). *Lepidop.*
'22. Bartley, Hastings N., 716 Commerce Bldg., Erie, Pa.
'18. Basinger, A. J., Citrus Expt. Sta., Riverside, Calif. *Citrus Insects.*
'22. Batchelder, Charles H., 170 Beech Ave., Melrose, Mass. *Ins. Pathology.*
'24. Beamer, Raymond H., 1000 Missouri St., Lawrence, Kans. *Cicadidæ.*
'20. Bedford, Hugh W., Khartoum, Sudan, Africa.

'24. Beebe, William, 33 W. Sixty-seventh St., New York City, N. Y.
'26. Bell, Ernest L., 438 Amity St., Flushing, N. Y. *Hesperiidæ.*
'26. Belón, Fernando, Apartado 133, Arequipa, Peru, S. A.
'15. Benjamin, Foster H., Box 499, Brownsville, Texas. *Lepidopt.*
'14. Bensel, G. E., Box 154, Spreckles, Calif.
Ch. Bentley, G. M., 406 Morrill Hall, Univ. Tenn., Knoxville, Tenn.
'23. Benton, Curtis, Box 495, W. Lafayette, Indiana. *Ecology.*
'17. *Bequaert, Joseph C., Harvard Medical School, Boston, Mass. *Hymenopt., Dipt.*
'09. Berger, E. W., 223 W. Ninth St. S., Gainesville, Fla. *Coccidæ, Aleyrodidæ.*
Ch. BETHUNE, CHARLES J. S., 16 Washington Ave., Toronto, Canada. (F. '06, HF. '14).
Ch. Betten, Cornelius, 3 The Circle, Ithaca, New York. *Trichoptera.*
Ch. BEUTENMULLER, WM., Elm St., Tenafly, N. J. (F. '08). *Cynipidæ.*
'28. Bieberdorf, G. A., A. & M. College, Dept. Ent., Stillwater, Okla. *Aphididæ.*
'26. Bigger, John Henry, 1114 S. Main St., Jacksonville, Ill.
'28. Bibby, F. F., Presidio, Texas.
'13. Bilsing, S. W., College Station, Texas. *Cerambycidæ, Acrididæ.*
Ch. Bird, Henry, 600 Milton Road, Rye, N. Y. *Noctuidæ.*
'27. Bird, Ralph D., Birtle, Manitoba, Canada. *Saw Flies.*
Ch. Bishopp, F. C., Bur. Ent., Washington, D. C. *Siphonaptera, Anopleura, Ixodoidea.*
'24. Bishop, Sherman C., N. Y. State Mus., Albany, N. Y. *Spiders, Phalangids.*
'26. Bissell, Theodore L., P. O. Box 271, Barnesville, Georgia. *Halticinæ, Aphididæ.*
'13. Blackman, M. W., N. Y. S. Coll. Forestry, Syracuse, N. Y. *Ipidæ, Cerambycidæ, Buprestidæ.*
Ch. BLAISDELL, F. E., Sr., Ent. Dept., Calif. Acad. Science, Golden Gate Park, San Francisco, Calif. (F. '25). *Tenebrionidæ, Melyridæ.*
'26. BLATCHLEY, W. S., 1558 Park Ave., Indianapolis, Ind. (F. '27). *Coleop., Orthop., Heterop.*
'26. Bolster, Percy G., 217 Norfolk St., Dorchester Center, Boston, Mass.
'26. Booth, O. E., 907 Clinton Ave., Des Moines, Iowa.
'14. Böeving, Adam C., U. S. Nat. Mus., Washington, D. C. *Coleopterous larvæ.*
'28. Borror, D. J., 177 W. Park Ave., Columbus, Ohio.
'24. Bowe, Martin, 27 Gladstone St., Providence, R. I. *Coleoptera.*
'23. Bowen, W. W., Wellcome Trop. Res. Lab., Khartoum, Sudan, Africa. *Cotton Ins.*
'17. Bowers, H. L., 31 N. Eastfield Ave., Trenton, N. J.
Ch. BRADLEY, J. CHESTER, Cornell Univ., Ithaca, N. Y. (F. '14). *Hymenopt.*
'19. Bradley, George H., Mound, La. *Diptera.*
'22. Branch, Hazel E., 3756 East Douglas Ave., Wichita, Kans. *Chironomidæ, Membracidæ.*
'26. Brandhorst, Carl T., Bremen, Kans.
Ch. BRAUN, ANNETTE F., 2702 May St., Cincinnati, O. (F. '25). *Microlepidoptera.*
'27. Breakley, E. P., State Ent. Office, Dept. of Agr., Madison, Wis.
'23. Brethes, Juan, Mar Chiquita, 5033, General Urquiza (F. C. C. A.), Buenos Aires, Rep. Argentina.
'27. Brittain, W. H., MacDonald College P. O., Quebec, Canada. *Homop.*
Ch. BRITTON, W. E., Agr. Exp. Sta., New Haven, Conn. (F. '14). *Aleyrodidæ, Coccidæ.*
'19. Bromley, Stanley W., Amer. Cyanamid Sales Co., 535 Fifth Ave., New York City, N. Y. *Asilidæ, Tabanidæ.*
Ch. Brooks, Fred E., French Creek, W. Va. *Fruit & Nut Ins.*
'26. Brown, W. J., Ent. Branch, Dept. Agr., Ottawa, Canada. *Coleop.*
'28. Bruce, Wesley G., Dept. Ent., State Agr. Coll., Manhattan, Kans.
Ch. BRUES, C. T., Bussey Inst., Boston 30, Mass. (F. '14). *Hymenopt.*
Ch. BRUNER, LAWRENCE, 3033 Deakin St., Berkeley, Calif. (F. '07). *Orthopt.*
'28. Brunson, M. H., Dept. Ent., Iowa State Coll., Ames, Iowa. *Strawberry Ins.*
'19. Bryan, Edwin H., Jr., Bishop Mus., Honolulu, Hawaii. *Dipt.*
'23. Bryson, Harry R., Dept. Ent., Agr. Coll., Manhattan, Kans. *Elateridæ.*

'28. Buckell, Edw. R., Box 308, Ent. Lab., Vernon, B. C., Canada. *Orthop.*
Ch. Bueno, J. R. de la Torre, 11 N. Broadway, White Plains, N. Y. *Aquatic Hemiptera.*
'22. Bulger, Jacob W., Bur. Ent. U.S.D.A. Washington, D. C. *Physiol., Hymenop.*
Ch. BURGESS, A. F., 964 Main St., Melrose Highlands, Mass. (F. '17). *Carabidæ.*
'28. Burrell, R. W., Jap. Beetle Lab., Moorestown, N. J.
'28. Burris, T. H., R. R. No. 10, Ballinger, Tex. *Ichneumonidæ.*
'19. Buys, John L., St. Lawrence Univ., Canton, N. Y. *Cicadellidæ.*
'24. Byers, C. Francis, Dept. Biol., Univ. Fla., Gainesville, Fla. *Odonata.*

'12. CAESAR, LAWSON, Ont. Agr. Coll., Guelph, Ontario. (F. '17).
'26. Caffrey, Donald J., 10 Court St., Arlington, Mass.
'17. Calder, Edwin E., R. I. Coll. Pharmacy, 235 Benefit St., Providence, R. I.
Ch. CALVERT, PHILIP P., Zool. Lab., Univ. of Pa., Phila., Pa. (F. '07). *Odonata.*
'24. Camacho, Carlos, Casilla 1248, Santiago, Chile.
'13. Campbell, Roy E., Box 297, Alhambra, Calif. *Syrphidæ.*
'14. *Capp, S. B., Box 2054, Phila., Pa.
'15. Carnochan, Frederic G., New City, Rockland Co., N. Y. *Coleoptera.*
'26. Carpentier, Fritz, Institut Ed. Van Beneden, 10 Rue Vivegnis, Liege, Belgium. *Morphology.*
'22. Carter, Walter, Box 1100, Twin Falls, Idaho. *Sphecoidea.*
'27. Cartwright, Oscar L., Oswego, S. C. *Scarabeidæ, Cicindelidæ.*
'17. Cartwright, W. B., 600 Twenty-sixth St., Sacramento, Calif.
'24. Cassino, S. E., 20 Naples Road, Salem, Mass. *Geometridæ.*
'18. CAUDELL, A. N., U. S. Nat. Mus., Wash., D. C. (F. '28). *Orthoptera.*
'14. Chaffee, Mrs. Gertrude B., Amenia, N. D.
'24. Chamberlain, K. F., 196 Western Ave., Albany, N. Y. *Cerambycidæ, Chrysomelidæ, Gyrinidæ.*
'22. Chamberlin, J. C., Box 2452, Stanford Univ., Calif. *Coccidæ, Chelonithida.*
Ch. CHAMBERLIN, R. V., Univ. Utah, Salt Lake City, Utah. (F. '17). *Arachnida, Myriopoda.*
'17. Chambers, E. L., Room 14, Capitol Annex, Madison, Wis.
'14. Champion, H. G., Forest Res. Inst., Dehca Dun, U. P., India. *Coleoptera.*
'21. Chandler, S. C., Route 5, Carbondale, Ill.
'14. CHAPMAN, R. N., Univ. Farm, St. Paul, Minn. (F. '28). *Ecology.*
'17. Chermock, Hugo L., 1308 Tell St., North Side, Pittsburgh, Pa. *Lepidop., Coleop.*
'13. Childs, Leroy, Hood River, Oregon.
'26. Chu, Yuanting T., St. Johns Univ., Shanghai, China. *Plecop.*
'18. Claassen, P. W., Cornell Univ., Ithaca, N. Y. *Plecoptera.*
'28. Clagg, C. F., Fernald Hall, Mass. Agric. Coll., Amherst, Mass. *Mecop., Hemip.*
'23. Clark, S. W., 132 Andrew Place, West Lafayette, Ind.
'27. Clarke, Floyd L., Newton, Utah.
'14. Clausen, Curtis P., Jap. Beetle Lab., Moorestown, N. J. *Parasitic Hymenop.*
'26. Cleveland, C. R., 318 Gladville Ave., Homewood, Ill.
'17. Coad., B. R., Tallulah, La.
'07. COCKERELL, T. D. A., 908 Tenth St., Boulder, Colo. (F. '08). *Bees, Fossil Insects.*
'16. Cole, Frank R., 31 Mountain View Ave., Santa Cruz, Calif. *Hymenoptera, Diptera.*
'27. Coleman, Laurence Vail, 4 W. Underwood St., Chevy Chase, Md. *Sense Organs, Hymenop.*
'21. Coleman, Wallace, Insecticide Lab., Vienna, Va. *Diptera.*
'16. Collins, C. W., Gipsy Moth Lab., Melrose Highlands, Mass. *Calosoma.*
'21. Compton, Charles C., Box 12, Aurora, Ill. *Greenhouse Ins.*
Ch. COMSTOCK, JOHN HENRY, Cornell Univ., Ithaca, N. Y. (F. '06; H. F. '14).
Ch. Cook, Mel T., Insular Exp. Sta., Rio Piedras, P. R. *Entomogenous Fungi.*
'19. Cook, William C., Mont. State Coll., Bozeman, Mont. *Noctuidæ.*
' 10. COOLEY, R. A., State Coll., Bozeman, Mont. (F. '25). *Diaspinæ.*

'21. Costa-Lima, Angelo Da, Casa Luiz de Rezende-Rua do Ouridor 116, Rio de Janeiro, Brazil. *Nycteribiidæ.*
'15. Cotton, Richard T., Bur. Ent., Wash., D. C. *Curculionidæ Larvæ.*
'21. Cowles, Raymond B., Cornell Univ., Ithaca, N. Y. *Coleopt., Hymenopt.*
'28. Craig, F. W., 315 Center St., Charleston, W. Va. *Cicadellidæ.*
'11. *Crampton, Guy C., 86 Pleasant St., Amherst, Mass. (F. '17). *Morphology.*
'12. Creel, Cecil W., Univ. Nev., Reno, Nev.
Ch. Cresson, Ezra T., Jr., 11 Amherst Ave., Swarthmore, Pa. (F. '25). *Ephydridæ, Micropezidæ.*
Ch. Criddle, Norman, Treesbank, Manitoba, Canada. *Orthopt., Coleopt.*
Ch. Crosby, C. R., Roberts Hall, Ithaca, N. Y. *Araneæ, Opiliones.*
'14. Crossman, S. S., 964 Main St., Melrose Highlands, Mass. *Parasitic Hymenopt.*
'15. Curran, C. H., Ent. Branch, Ottawa, Canada. *Dipt.*
'21. Cutright, C. R., Ohio Agr. Exp. Sta., Wooster, Ohio. *Aphididæ.*

'26. Darlington, Phillip J., Jr., Care United Fruit Co., Rio Frio, Colombia, S. A. *Bembidion, Brachinus, Elaphrini.*
'13. Davidson, W. M., U. S. Insecticide Lab., Vienna, Va. *Syrphidæ, Coccinellidæ, Aphididæ.*
'28. Davis, A. C., P. O. Box 387, Garden Grove, Calif. *Coleop.*
'27. Davis, Cecil N., 108 Whitten Hall, Columbia, Mo.
'22. Davis, Edgar W., Box 342, Richfield, Utah. *Cicadellidæ.*
Ch. Davis, John J., Purdue Univ., Lafayette, Ind. (F. '17). *Aphididæ, Lachnosterna.*
Ch. *Davis, William T., 146 Stuyvesant Pl., Staten Id., N. Y. (F. '17). *Cicadidæ, Orthop.*
'26. Deay, Howard O., 107 E. 19th St., Lawrence, Kans.
'13. Dean, George A., Kans. State Agr. Coll., Manhattan, Kans. (F. '17).
'24. Decker, George C., Dept. Zool., Iowa State Coll., Ames, Iowa.
'24. De Coursey, R. M., Dept. of Ent., Old Law Bldg., Urbana, Ill.
'17. De Garnett, R. T., 135 Arbor Drive, Piedmont, Alameda Co., Calif. *Buprestidæ, Cicindelidæ, Carabidæ.*
'28. De Gant, F. D., 3401 Wade Ave., Cleveland, Ohio.
'14. De Gryse, Joseph J., Ent. Branch, Dept. Agr., Ottawa, Canada.
'14. DeLong, D. M., Dept. Ento., Ohio State Univ., Columbus, O. *Cicadellidæ, Homoptera.*
'19. Detwiler, John D., 844 Hellmuth Ave., London, Ontario.
'28. Dicke, F. F., U. S. Corn Borer Lab., Monroe, Mich.
'22. Dietrich, Henry, Appleton, N. Y. *Coleopt.*
Ch. Dietz, Wm. G., 21 North Vine St., Hazelton, Pa. *Tipulidæ.*
'24. Dills, Leslie E., Inwood, W. Va.
'26. Dirks, C. O., Dept. Biol., Univ. of Maine, Orono, Me.
'28. *Doak, K. D., Purdue Univ. Agr. Exp. Sta., Lafayette, Ind. *Gelechiidæ.*
Ch. Doane, R. W., Stanford University, Calif. (F. '25).
'22. Doering, Kathleen C., 1214 Tenn. St., Lawrence, Kans. *Cercopidæ.*
'22. Dohanian, S. M., 42 Cedar St., W. Somerville, Mass. *Parasitic Hymenopt.*
'22. Doucette, Charles F., West Wash. Exp. Sta., Puyallup, Wash. *Greenhouse Insects.*
'23. Douglass, J. R., Box 353, Estancia, New Mex. *Chrysomelidæ.*
'22. Dowden, Philip B., Tars Utca 3, Budapest I, Hungary. *Parasitic Hymenopt.*
'17. Dowell, Philip, 86 Bond St., Port Richmond, Staten Id., N. Y.
'26. Dozier, H. L., Delaware Exp. Sta., Newark, Del. *Homopt.*
'22. Drake, Carl J., Iowa State Coll., Ames, Iowa. *Tingitidæ.*
'25. Duffy, Leo F., Arlington, Vermont.
'26. Dunavan, David, Dept. Ent., Clemson College, S. C. *Carabidæ.*
'23. Duncan, Carl D., State Teachers Coll., San Jose, Calif. *Vespidæ, Bembicidæ.*
'24. Dunn, Melvin B., Ent. Branch, Ottawa, Canada.
'16. Du Porte, E. Melville, MacDonald Coll., Quebec, Canada. *Diptera, Ixodoidea.*
'14. Dusham, E. H., Dept. Ent., State Coll., Pa. *Coleoptera.*

Ch. Easton, Norman S., 458 High St., Fall River, Mass. *Coleoptera.*
'26. Eaton, Theodore H., Jr., 105 Brandon Pl., Ithaca, N. Y.
'23. Eddy, C. O., Clemson College, S. C.
'13. Edmonston, W. D., Jordan Hall, Stanford Univ., Calif. *Scolytidæ.*
Ch. Edwards, Edwin H., 1548 Rockway Ave., Lakewood, Ohio. *Coleop.*
'24. Elmore, John C., Box 66, Garden Grove, Calif.
— '17. Elrod, M. J., 205 South Fifth St., Missoula, Mont. *Odonata.*
'28. Elson, J. A., St. Peter, Minn. *Hemip.*
'11. Ely, Charles R., 6 Kendall Green, Wash., D. C. *Gracilariidæ.*
— '19. Emerson, Alfred E., Dept. Zool., Univ. Pittsburgh, Pittsburgh, Pa. *Isopt.*
— Ch. EMERTON, J. H., 30 Ipswich St., Boston, Mass. (F. '07). *Spiders.*
'14. Enburg, John M., 5207 Baltimore Ave., Phila., Pa.
'26. Enders, Howard E., 249 Littleton St., W. Lafayette, Ind. *Mallophaga.*
— Ch. Englehardt, George P., Museum, 373 Ocean Ave., Brooklyn, N. Y. *Aegeriidæ.*
'26. English, Lester Lemar, Chamb. Spring Hill, Ala.
'22. Esaki, Teiso, Ent. Lab., Coll. Agr., Kiushiu Imperial University, Fukuoka, Japan. *Heteropt.*
'10. ESSIG, E. O., Room 201, A. H., Univ. Calif., Berkeley, Calif. (F. '27). *Aphididæ, Coccidæ.*
Ch. Ewers, Lt. Col. William V., Les Reverants, Somerset, Bermuda.
'10. Ewing, H. E., U. S. Nat. Mus., Wash., D. C. *Acarina.*
'18. Eyer, John R., Biol. Dept., State College, N. Mex. *Tineodea.*

'17. Fackler, Harry L., Exp. Sta., Univ. Tenn., Knoxville, Tenn.
— Ch. FALL, H. C., Tyngsboro, Mass. (F. '07). *Coleopt.*
'17. Fattig, P. W., P. O. Box 788, Emory Univ., Georgia.
'23. Faz, Alfredo, Calle Bandera No. 714, Santiago, Chile, S. A.
Ch. FELT, E. P., Bartlett Res. Lab., Stamford, Conn. (F. '08). *Itonididæ.*
'15. Fenton, A. F., 1013 Mills Bldg., El Paso, Tex. *Dryinidæ.*
Ch. FERNALD, H. T., Mass. Agr. Coll., Amherst, Mass. (F. '14). *Sphecidæ.*
'14. Ferris, G. F., Stanford University, Calif. *Coccidæ, Chermidæ, Ectoparasites.*
'27. Ficht, G. A., U. S. Corn Borer Lab., Monroe, Mich.
Ch. Field, W. L. W., Milton Academy, Milton, Mass. *Lepidopt.*
'27. Fife, Lorin, 345 N. Third St., Logan, Utah.
'22. Filinger, George A., Dept. Ent., Agr. Exp. Sta., Wooster, Ohio. *Greenhouse Ins.*
'10. Fink, D. E., Zool. Lab., Univ. of Pa., Phila., Pa. *Physiology.*
'28. Fisher, C. K., 1218 Eye St., Modesto, Calif.
'07. Fisher, W. S., U. S. Nat. Mus., Wash., D. C. *Buprestidæ, Cerambycidæ.*
'22. Fletcher, Frank C., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Tenebrionidæ, Pselaphidæ.*
'19. Fletcher, Robert K., Box 152, Faculty Exchange, College Station, Tex. *Homop.*
'08. Flint, W. P., State Ent. Bldg., Urbana, Ill.
'19. Florence, Dr. Laura, Apt. 3C, 445 E. 65th St., New York, N. Y. *Anoplura.*
'23. Fluke, Charles L., Dept. Econ. Ent., Univ. of Wis., Madison, Wis. *Syrphidæ, Bombyliidæ.*
+ Ch. FOLSOM, J. W., Delta Lab., Tallulah, La. (F. '07). *Collembola, Thysanura.*
Ch. FORBES, STEPHEN ALFRED, State Nat. Hist. Surv., Urbana, Ill. (F. '07; H. F. '15).
— '08. *Forbes, William T. M., Roberts Hall, Cornell Univ., Ithaca, N. Y. *Lepidopt.*
'22. Ford, Norma, Dept. Biol., Univ. Toronto, Toronto 5, Ontario. *Anat., Physiol.*
'19. Fournier, Mrs. Gaston, 90 Boulevard Malesherbes, Paris (8), France. *Lepidopt.*
— '26. Fout, Robert M., 730 Quebec St., N. W., Washington, D. C. *Serphoidea.*
'28. Fox, C. L., 1621 Vallejo St., San Francisco, Calif. *Bembicini, Nomadidæ.*
+ '12. Fox, Henry, Jap. Beetle Lab., Moorestown, N. J. *Orthopt., Scarabaeidæ.*
'11. Fracker, S. B., Fed. Hort. Board, Wash., D. C. *Coreidæ.*
+ '23. Freeborn, Stanley B., Univ. Farm, Davis, Calif. *Culicidæ.*
'22. Friend, Robert B., Agr. Exp. Sta., New Haven, Conn. *Diptera.*

'14. Frison, T. H., Nat. Hist. Bldg., Urbana, Ill. *Bremidæ, Evaniidæ.*
Ch. Frost, C. A., 67 Henry St., Framingham, Mass. *Coleoptera.*
'14. Frost, S. W., Arendtsville, Pa. *Agromyzidæ.*
Ch. Fullaway, D. T., Board of Agr., Box 3319, Honolulu, T. H. *Braconidæ.*
'27. Fuller, Paul B., 1717 Third Ave., Evansville, Ind. *Lepidop.*
'16. Fulton, B. B., N. C. State Coll., W. Raleigh, N. C. *Orthoptera.*
'11. FUNKHOUSER, W. D., Univ. of Kentucky, Lexington, Ky. (F. '20). *Membracidæ.*

Ch. Gahan, A. B., U. S. Nat. Mus., Wash., D. C. *Chalcidoidea, Braconidæ.*
'16. Gaige, Frederick M., Mus. Zool., Univ. of Mich., Ann Arbor, Mich. *Formicidæ.*
'22. Garlick, W. G., Vineland Station, Ontario, Canada. *Tenthredinoidea.*
'14. Garman, Philip, Conn. Agr. Exp. Sta., New Haven, Conn. *Odonata, Acarina.*
'22. Gehring, John George, Bethel, Maine. *Coleoptera.*
'16. Gentner, Louis G., 352 Marshall St., East Lansing, Mich. *Halticinæ.*
Ch. Gerhard, Wm. J., Field Mus. Nat. Hist., Chicago, Ill. *Hemiptera.*
'22. Gerry, Bertram, I., 20 Union Park, Boston, Mass.
Ch. GIBSON, ARTHUR, Dominion Entomologist, Ottawa, Canada. (F. '17).
'12. Gibson, Edmund H., 512 Old Orchard Road, Ten Hills, Baltimore, Md. *Hemip.*
'13. Gibson, Frank M., 235 W. Lafayette Ave., Baltimore, Md. *Lepidoptera.*
Ch. *Giffard, W. M., Box 300, Honolulu, T. H. *Delphacidæ.*
Ch. GILLETTE, C. P., Fort Collins, Colo. (F. '07). *Aphididæ.*
'28. Gilliatt, F. C., Ent. Lab., Annapolis Royal, Nova Scotia, Canada.
'22. Gilmer, Paul M., 2303 W. Douglas Ave., Wichita, Kans. *Hymenoptera.*
'16. Glaser, Rudolf W., Rockefeller Inst. for Med. Res., Princeton, N. J. *Insect Diseases.*
'11. Glasgow, Hugh, Exp. Sta., Geneva, N. Y.
'11. Glasgow, Robert D., State Mus., Albany, N. Y. *Phyllophaga.*
'21. Good, Henry G., Zool. & Ent., Auburn, Ala. *Coleoptera.*
'08. Goodwin, W. H., High School, North Lima, Ohio.
Ch. Graenicher, Sigmund, Box 14, S. Miami, Fla. *Muscoid Dipt.*
'24. Graf, John E., Bur. Ent., Wash., D. C.
'17. Graham, Samuel A., Sch. Forestry & Conservation, Univ. Mich., Ann Arbor, Mich. *Ipidæ, Cerambycidæ, Buprestidæ.*
'22. Granovsky, A. A., 1532 Univ. Ave., Madison, Wis. *Aphididæ.*
'26. Grant, Ulysses S. IV, Nat. Hist. Mus., Balboa Park, San Diego, Calif.
'28. Gray, John, Dept. Ent., Univ. Fla., Gainesville, Fla.
'14. Greene, Charles T., Box 182, College Park, Md. *Dipt.*
'24. Greer, Albert H., Room 8, Federal Bldg., El Paso, Tex. *Heterocera, Culicidæ.*
'19. Griswold, Grace H., Dept. Ent., Cornell Univ., Ithaca, N. Y.
'24. Gui, Harry L., Agric. Exp. Sta., Wooster, Ohio.
'21. Guyton, F. E., Auburn, Ala. *Cicadellidæ.*
'16. Guyton, T. L., Bur. Plant Industry, Dept. Agr., Harrisburg, Pa. *Aphididæ.*

'26. Haber, Vernon R., Dept. of Ent., State College, Pa. *Orthop.*
'27. Hadden, Fred C., P. O. Box 411, Honolulu, T. H. *Brichidæ, Bostrychidæ, Histeridæ.*
'23. Hadley, Charles H., U. S. Bur. Ent., Riverton, N. J.
'24. Haeussler, Gilbert J., U. S. Bur. Ent., Moorestown, N. J.
'14. Hagan, Harold R., Zool. Dept., Univ. Utah, Salt Lake City, Utah. *Dipt.*
'26. Haigh, Margaret, 462 Garrison W., Dearborn, Mich. *Lepidop.*
'26. Hall, David G., Dept. Ent., Univ. Ark., Fayetteville, Ark. *Sarcophagidæ.*
'22. Hall, Maurice C., Zool. Div., Bur. Animal Industry, Washington, D. C. *Parasites of domestic animals.*
'14. Hallinen, J. E., Coopertown, Kiowa Co., Oklahoma. *Bionomics.*
'21. Hallock, Harold H., P. O. Box 764, Westbury, L. I., N. Y. *Dipt., Sarcophagidæ.*

'14. Hamilton, Clyde C., Rutgers College, New Brunswick, N. J. *Larvæ of Cincindelidæ and Carabidæ.*
'28. Hamilton, Lysbeth L., Dept. Zool., Univ. Pittsburgh, Pittsburgh, Pa.
'16. Hamlin, John C., Care Dept. Ent., Ohio State Univ., Columbus, Ohio. *Membracidæ, Chelinidæ.*
Ch. Hansen, James, St. John's Univ., Collegeville, Minn.
'26. Haren, Wm. A., 4575 Forest Park Blvd., St. Louis, Mo.
'07. HARNED, R. W., Agricultural College, Miss. (F. '28).
'23. Harris, Halbert M., Dept. Zool., State Coll., Ames, Iowa. *Hemip., Nabidæ, Anthocoridæ.*
'28. Harrison, Perry K., Box 415, Picayune, Miss.
'24. Hart, Cecil, 132 N. Third St., Montebello, Calif.
'20. Hartzell, Albert, 1086 N. Broadway, Boyce Thompson Inst., Yonkers, N. Y. *Cicadellidæ.*
'07. Hartzell, F. Z., Exp. Sta., Geneva, N. Y. *Coleoptera.*
Ch. Haseman, Leonard, Univ. of Missouri, Columbia, Mo. *Psychodidæ.*
'19. Hatch, Mellville H., Dept. Zool., Univ. of Wash., Seattle. *Coleopt., Histeridæ.*
'28. Hawkins, J. H., Agr. Exp. Sta., Orono, Maine. *Lepidop larvæ.*
'19. Hayes, Wm. P., Old Law Bldg., Univ. Illinois, Urbana, Ill. *Immature Insects.*
Ch. HEADLEE, THOMAS J., New Brunswick, N. J. (F. '20).
'28. Hearle, Eric, Indian Head, Saskatchewan, Canada. *Culicidae.*
'27. Hendrickson, Geo. O., Dept. Ent., Iowa State Coll., Ames, Iowa. *Prairie Ins.*
Ch. HENSHAW, SAMUEL, 28 Fayerweather St., Cambridge, Mass. (F. '07).
'26. Herms, Wm. B., Agr. Hall, Univ. Calif., Berkeley, Calif.
Ch. HERRICK, GLENN W., 219 Kelvin Pl., Ithaca, N. Y. (F. '14). *Thysan., Coccidæ.*
'20. Hertig, Marshall, Dept. Comp. Path., Harvard Med. Sch., Boston, Mass. *Insect Symbionts.*
'17. Hertzog, P. H., Highstown, N. J.
'16. Hess, Walter N., DePauw Univ., Greencastle, Ind. *Lampyridæ.*
'08. Heywood, Mrs. R. E., The Oaks, Peterson, Ia.
'26. Higgins, M. L. J., Rood Ave., Sta. 14½, Windsor, Conn. *Coleop.*
'19. Hill, Chas. C., 337 Franklin St., Carlisle, Pa.
'08. Hilton, W. A., 1263 Dartmouth Ave., Claremont, Calif. *Campodea, Japyx.*
'28. Hiltz, Josiah R., 240 Florence Ave., Pontiac Mich.
Ch. HINDS, W. E., Louisiana State Univ., Baton Rouge, La. (F. '25).
Ch. HINE, JAS. S., Ohio State Univ., Columbus, Ohio. (F. '14). *Dipt.*
'28. Hinman, E. H., 315 Dryden Rd., Ithaca, N. Y.
'27. Hochenyos, Geo. L., 364 W. Reynold St., Springfield, Ill. *Greenhouse Ins.*
Ch. Hodgkiss, H. E., Exp. Sta. Bldg., State College, Pa. *Eriophyidæ.*
'17. Hofer, Geo., Box 1658, Tucson, Ariz. *Forest Ins., Coleop.*
'14. *Hoffman, Wm. A., Sch. Tropical Med., San Juan, P. R. *Ceratopogoninæ, Halticinæ.*
'19. Hoffmann, Wm. E., Dept. Biol., Lingnan Univ., Honglok, Canton, China. *Aquatic Hemipt.*
'19. Hoke, Gladys, A. & M. College, Miss. *Coccidæ, Thysanop., Aleurod.*
'28. Holdaway, F. G., Div. Ent., Univ. Farm, St. Paul, Minn.
Ch. HOLLAND, W. J., Carnegie Mus., Pittsburgh, Pa. (F. '07).
'13. Holloway, T. E., 8203 Oak St., New Orleans, La.
'12. Hood, C. E., Melrose Highlands, Mass.
Ch. Hood, J. D., Dept. Biol., Univ. Rochester, Rochester, N. Y. *Thysanoptera.*
'28. Hopping, R., Box, 308, Vernon, Brit. Col., Canada. *Coleop. of Woods.*
'13. Horton, J. R., 126 S. Minneapolis Ave., Wichita, Kans. *Phyllophaga, Formicidæ.*
'23. Hottes, Frederick C., 707 N. Seventh St., Grand Junction, Colo. *Aphididæ.*
'24. Hough, Walter S., Winchester, Va.
Ch. Houser, J. S., Agr. Exp. Sta., Wooster, Ohio.
Ch. Howard, Chas. T., 1735 East Ave., Rochester, N. Y. *Lepidopt.*

Ch. *HOWARD, LELAND O., U. S. Bur. Ent., Washington, D. C. (F. '07; H. F. '24). *Parasitic Hymen., Culicidæ.*
'14. Howard, Neale F., 151 W. Eleventh Ave., Columbus, Ohio.
Ch. Huard, V. A., 2 Richelieu St., Quebec, Canada. *Lepidopt.*
'23. Hubbell, T. H., Dept. Biol., Univ. Fla., Gainesville, Fla. *Orthopt.*
'21. Huber, L. L., 1150 N. Bever St., Wooster, Ohio. *Chalcidoidea.*
'19. Huckett, Hugh C., R. F. D., Calverton, L. I., N. Y. *Anthomyiidæ, Muscidæ.*
'28. Hudson, H. F., Ent. Lab., Strathroy, Ont., Can.
'22. Hull, Frank M., Box 277, Angleton, Tex. *Dipt.*
'09. Hungate, J. W., State Normal School, Cheney, Wash.
'16. HUNGERFORD, H. B., 202 Mus. Bldg., Lawrence, Kans. (F. '28). *Aquatic Hemipt.*
Ch. HUNTER, S. J., Lawrence, Kans. (F. 21).
'17. Hussey, Roland F., Biol. Dept., New York Univ., Wash. Sq., New York City, N. Y. *Hemipt.*
'26. Hutchinson, Wilbur L., Main St., Conyngham, Pa. *Coleop.*
'08. Hyslop, J. A., Silver Spring, Md. *Elateridæ.*

'11. *Illingworth, J. F., Bishop Mus., Honolulu, T. H. *Muscoidea.*
'28. Ingram, J. W., Box 164, Crowley, La.
'26. Irish, Henry Clay, 911 Locust St., St. Louis, Mo.
'14. Isely, Dwight, 3 N. Duncan St., Fayetteville, Ark.
'22. Ishimori, Naoto, Uyeda, Naganoken, Japan. *Lepidopt.*
'27. Ives, J. D., Carson & Newman Coll., Jefferson City, Tenn.

'07. Jackson, C. F., Durham, N. H. *Ecology.*
'15. Jackson, L. O., High School, Colorado Springs, Colo. *Fossorial Wasps.*
'24. Janvrin, E. R. P., 38 E. 85th St., New York, N. Y. *Coleopt.*
'25. Jeannel, R., Mus. D'Histoire Naturelle, 57 Rue Cuvier, Paris 5e France. *Trechinæ.*
'10. Jennings, H. R., High School of Commerce, Hayes and Van Ness Aves., San Francisco, Calif. *Dipt.*
'15. Jewett, H. H., Agr. Exp. Sta., Lexington, Ky.
Ch. JOHANNSEN, O. A., Dept. Ent., Cornell Univ., Ithaca, N. Y. (F. '14). *Dipt.*
Ch. JOHNSON, CHAS. W., Bost. Soc. Nat. Hist., 234 Berkeley St., Boston, Mass. (F. '07). *Dipt.*
'26. Johnson, Frank, Room 1775, 50 Church St., New York, N. Y.
'25. Johnson, Karl W., Archer, Iowa.
Ch. Johnson, S. Arthur, State Agr. Coll., Ft. Collins, Colo.
'27. Johnston, H. G., Ent. Dept., College Station, Tex. *Miridæ.*
'26. Jones, Dettmar W., 10 Court St., Arlington, Mass. *Tachinidæ.*
'28. Jones, Elmer T., 126 S. Minneapolis Ave., Wichita, Kans.
Ch. Jones, Frank M., 2000 Riverview Ave., Wilmington, Del. *Psychidæ.*
'26. Jones, W. Russell, R. F. D. 11, Box 63-B, Pensacola, Fla. *Hymenop.*

'16. Kahl, Hugo, Carnegie Mus., Pittsburgh, Pa. *Odonata, Dipt.*
'27. Kamel, Mohammed, Cotton Research Bd., Giza, Egypt. *Syrphidæ, Coccidæ.*
'21. Keen, Sadie E., Box 45, Forest Grove, Ore. *Coccinellidæ, Micro Lepid.*
Ch. KELLOGG, VERNON, Nat. Res. Council, 1701 Mass. Ave., Wash., D. C. (F. '07).
'23. Kelly, E. G., State Agr. Coll., Manhattan, Kans.
'24. Kelsheimer, Eugene G., Corn Borer Labr., Oak Harbor, Ohio. *Behavior.*
'14. KENNEDY, C. H., Dept. Ent., Ohio State Univ., Columbus, Ohio. (F. '28). *Odonata.*
Ch. Kincaid, Trevor, Univ. Wash., Seattle, Wash. *Psychodidæ, Tenthredionidea.*
'28. King, Geo. E., A. & M. Coll., Stillwater, Okla. *Hymenop.*
'14. King, H. H., Wellcome Trop. Res. Labr., Khartoun, Sudan, Africa.
'12. King, J. L., Jap. Beetle Labr., Moorestown, N. J. *Dipt.*
'23. King, Kenneth M., Univ. of Sask., Saskatoon, Sask., Can. *Noctuidæ, Cicadellidæ.*
'18. Kinsey, Alfred C., Ind. Univ., Bloomington, Ind. *Cynipidæ.*
'25. Kistler, Alfred J., 775 Forest Ave., Bronx, N. Y. *Cincidnellidæ.*

'11. Knight, Harry H., State College, Ames, Ia. *Miridæ.*
Ch. KNAUS, W., McPherson, Kans. (F. '20). *Coleopt.*
'24. Knowlton, Geo. F., Dept. Ent., Agr. Exp. Sta., Logan, Utah. *Aphididæ.*
'26. Kofoid, Chas. A., Univ. Calif., Berkeley, Calif. *Termitidæ.*
'17. Kraatz, Walter C., Univ. of Akron, Akron, Ohio.
'23. Krafka, Jos., Jr., Le Conte Hall, Univ. of Ga., Athens, Ga. *Trichopt., Dipt.*
'23. Kuwayama, Satoru, Hokkaido Agr. Exp. Sta., Kotoni, Sapporo, Japan. *Neuropt., Mecopt., Trichopt., Psyllidæ.*

'14. Laake, E. W., Box 208, Dallas, Tex. *Immature Muscidæ, Oestridæ.*
'24. Lacy, John S., 13 Elm St., Holyoke, Mass.
'19. LaCroix, Don S., 1224 W. Jefferson St., Sandusky, Ohio.
Ch. Lagai, Geo., 8533 110th St., Richmond Hill, L. I., N. Y. *Lepidopt.*
'12. Lamkey, Ernest M. R., 801 Washington St., Wilmington, Del.
Ch. Lang, Joseph N., 1433 S. 59th Ave., Cicero, Ill. *Lepidop.*
'17. Lange, Richard C., 527 Ivanhoe Pl., Webster Grove, Mo. *Coleopt., Lepidopt.*
'26. Langford, Geo. S., Exp. Sta. Wooster, Ohio. *Orthopt.*
'17. Langston, J. M., Box 597, A. & M. Coll., Miss. *Phyllophaga.*
'14. Larrimer, W. H., Bur. Ent., Dept. Agr., Washington, D. C. *Cicadellidæ.*
'26. Larson, Andrew O., Box 297, Alhambra, Calif.
'13. Lathrop, Frank H., Cherryfield, Me. *Cicadellidæ.*
'19. Lathy, Percy I., 90 Bd. Malesherbes, Paris, France. *Lepidopt.*
'24. Lattimore, Robt. B., 701 Polk Ave., Houston, Tex.
'23. Lauderdale, Jos. L. E., Box 368, Yuma, Ariz.
Ch. Laurent, Philip, 31 E. Mt. Airy Ave., Phila., Pa.
'27. Lawler, Wm. F., Jr., 38 Murray St., New York, N. Y. *Satyridæ.*
'17. Lawson, Paul B., 635 Main St., Lawrence, Kans. *Cicadellidæ.*
'26. Leach, Frank A., Diable Country Club, Diable, Calif.
'22. Learned, Elmer T., 46 Franklin St., Fall River, Mass. *Lepidopt.*
'12. Leiby, R. W., State Dept. Agr., Raleigh, N. C. *Polyembryony.*
'26. Lermond, Norman W., Thomaston, Me. *Coleop.*
'27. Letl, Frank H., Dept. of Preparation, Field Mus. Nat. Hist., Chicago, Ill.
'27. Light, S. F., Dept. Zool., Univ. Calif., Berkeley, Calif. *Isopt.*
'17. Lindsey, A. W., Box 782, Granville, Ohio. *Hesperiidæ.*
'26. List, Geo. M., State Agr. Coll., Ft. Collins, Colo. *Cimicidæ.*
'24. Liu, Chung Lo., Dept. Biol., Tsing Hua Coll., Peking, China. *Vespidæ, Bombidæ.*
Ch. Lloyd, J. T., 6624 Kennedy Ave., Cincinnati, Ohio. *Trichoptera.*
Ch. Lockwood, Stewart, Box 1094, Ent. Labr., Billings, Mont.
'26. Long, Wm. W., Eighty-four, Pa. *Lepidop.*
'19. Lowry, P. R., New Hampshire Coll., Durham, N. H.
'13. Luginbill, Philip, Drawer 359, U. S. Ent. Labr., Monroe, Mich.
'17. Lundbeck, Wm., Zoological Mus., Copenhagen, Denmark. *Dipt.*
Ch. LUTZ, FRANK E., Amer. Mus. Nat. History, New York, N. Y. (F. '17). *Bees.*

'14. McAtee, W. L., Biol. Survey, Dept. Agr., Washington, D. C. *Hemipt.*
'20. McBride, O. C., Box 491, Orlando, Fla. *Cerambycidæ, Buprestidæ.*
'17. McColloch, Jas. W., Agr. Exp. Sta., Manhattan, Kans. *Scarabaeidæ.*
'07. McCracken, Isabel, Box 44, Stanford University, Calif. *Cynipidæ, Apoidea.*
'10. McDaniel, Eugenia I., Agr. Coll., East Lansing, Mich. *Coccidæ.*
'24. MacDougal, Alice Pearce, Biol. Dept., Univ. Toronto, Toronto, Can. *Hemip.*
'12. McDUNNOUGH, J., Ent. Branch, Dept. Agr., Ottawa, Can. (F. '20). *Lepidop., Ephemerida.*
'25. McGeoch, Chas. R., Salisbury, Conn.
'25. McGregor, Ernest A., Box 576, Lindsay, Calif. *Tetranychidæ.*
'11. McIndoo, N. E., Bur. Ent., Dept. Agr., Washington, D. C. *Physiology.*
'21. McNeill, Jerome, Thonotosassa, Fla. *Orthopt.*

'23. Mabee, W. Bruce, Dept. Ent., Raleigh, N. C.
'17. Maheux, Georges, Parliament Bldg., Quebec, Can. *Buprestidæ, Cerambycidæ.*
'22. Mank, Edith W., 12 Reservoir St., Lawrence, Mass. *Coleopt.*
'21. Mank, Helen Gardner, 12 Reservoir St., Lawrence, Mass.
'13. *Mann, Wm. M., U. S. Nat. Mus., Washington, D. C. *Formicidæ.*
'23. Manter, Jerauld A., Agr. Coll., Storrs, Conn.
'22. Marcovitch, Simon, Agr. Exp. Sta., Knoxville, Tenn.
Ch. MARLATT, C. L., 1521 Sixteenth St., N. W., Washington, D. C. (F. '08). *Coccidæ.*
'24. Marshall, M. C., 213-12 Hollis Ave., Bellaire, L. I., N. Y.
Ch. MARSHALL, WM. S., 139 E. Gilman St., Madison, Wis. (F. '17). *Morphology.*
'26. Martin, Chas. H., P. O. Box 351, Albany, Ga. *Hemip.*
'21. Mason, Arthur C., Box 340, Honolulu, T. H. *Thysanoptera.*
'12. Mason, P. W., Bur. Ent., Dept. Agr., Wash., D. C. *Aphididæ.*
Ch. Matheson, Robt., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Blood-sucking Arthropoda.*
'23. Mathewson, A. A., Waterville, Ohio.
'28. Maughan, F. B., Wellsville, Utah.
'28. Maynard, E. A., Univ. of Rochester, Rochester, N. Y. *Collembola.*
'26. Meiners, Edwin P., 6600 Delmar Blvd., St. Louis, Mo. *Lepidop.*
Ch. MELANDER, A. L., Dept. Biol., Coll. of City of N. Y., St. Nicholas Terrace and 139th St., New York, N. Y. (F. '14). *Dipt.*
'28. Melvin, Roy, 2713 Boone St., Ames, Ia. *Physiol.*
'23. Merrill, Geo. B., State Plant Bd., Gainesville, Fla. *Coccidæ, Aleyrodidæ.*
'12. METCALF, C. L., Dept. Ent., Old Law Bldg., Univ. Ill., Urbana, Ill. (F. '20). *Syrphidæ.*
'09. Metcalf, Z. P., State Coll. Sta., Raleigh, N. C. *Homoptera.*
'17. Miekel, Clarence E., Ent. Div., Univ. Farm, St. Paul, Minn. *Mutillidæ.*
'21. Miller, August E., 1004 Garfield Ave., Urbana, Ill. *Acarina.*
Ch. Miller, Mrs. Ellen R., LakeWildmere, Longwood, Fla. *Lepidopt.*
'28. Miller, Ralph L., Dept. Ent., State Univ., Columbus, Ohio.
'26. Miller, Warren C., Bedford High Sch., Bedford, Ohio. *Hymenop., Coleop.*
'26. Mills, Wier R., Pierson, Ia. *Lepidop.*
'26. Milum, Vern G., 104 Vivarium Bldg., Univ. Ill., Champaign, Ill.
'26. Minnich, D. E., Dept. Zool., Univ. Minn., Minneapolis, Minn. *Behavior.*
'21. Mitchell, Theo. B., Dept. Zool., State Coll., Raleigh, N. C. *Apoidea.*
'21. *Moffatt, Elizabeth M., Wheaton, Ill. *Araneida.*
'22. Montgomery, B. Elwood, R. F. D. 3, Poseyville, Ind. *Coleopt., Odonata.*
'08. Moore, Wm., 535 Fifth Ave., New York, N. Y.
Ch. MORSE, ALBERT P., Peabody Mus., Salem, Mass. (F. '14). *Orthopt.*
'08. Morgan, Ann H., South Hadley, Mass. *Ephemeridæ.*
Ch. Morgan, H. A., Univ. of Tenn., Knoxville, Tenn.
'28. Morgan, W. P., 4105 Otterbein Ave., Indianapolis, Ind.
Ch. Morrill, A. W., 1434 Winchester Ave., Glendale, Calif. *Aleyrodidæ.*
'12. Morrison, Harold, Bur. Ent., Dept. Agr., Washington, D. C. *Coccidæ.*
'26. Mortensen, Ernest, P. O. Box 509, Uvalde, Tex. *Cerambycidæ, Calandridæ.*
'08. MOSHER, EDNA, Adelphia Coll., 282 Lafayette Ave., Brooklyn, N. Y. (F. '20). *Lepidop.*
'20. Mote, Don C., Agr., Coll., Corvallis, Ore.
'26. Muchmore, Lyman J., 2009 W. 65th St., Los Angeles, Calif. *Coleop., Arach.*
'26. Mueller, Arthur E., 12 Armin Ave., Webster Grove, Mo.
'15. Muesebeck, C. F. W., 17 E. Highland Ave., Melrose Highlands, Mass. *Chalcidoidea, Ichneumonoidea, Braconidæ.*
Ch. MUIR, FREDERICK, H. S. P. A. Exp. Sta., Honolulu, T. H. (F. '17). *Homop.*
'24. Munro, H. K., Box 513, Pretoria, S. Afr. *Syrphidæ, Trypaneidæ.*
'27. Munro, J. A., State Coll. Exp. Sta., Fargo, N. Dak. *Orthop., Hymenop.*
'28. Musgrave, P. N., 514 Mt. Vernon Ave., Fairmount, W. Va. *Cicadellidæ.*
'17. Mutchler, Andrew J., Amer. Mus. Nat. Hist., New York, N. Y. *Lampyridæ, Cicindelidæ.*
'15. Muttkowski, R. A., Dept. Zool., Univ. of Detroit, Detroit, Mich. *Physiol.*

Ch. NEEDHAM, JAMES G., 6 Thurston Ave., Ithaca, N. Y. (F. '07). *Odonata, Ephemerida, Plecopt.*
'27. Needham, Paul R., Oak Hill Place, Ithaca, N. Y. *Ecol.*
'21. Neilson, Ernest A., 143-16 97th Ave., Jamaica, L. I., N. Y.
'21. Neiswander, C. R., Oak Harbor, Ohio. *Aq. Hemip.*
'07. Nelson, Jas. A., Route 3, Mt. Vernon, Ohio.
Ch. Ness, H., 821 Kellogg Ave., Ames, Iowa.
Ch. Newcomb, W. W., 1245 Ferdon Rd., Ann Arbor, Mich. *Lepidopt.*
Ch. Newcomer, E. J., Box 243, Yakima, Wash.
†'07. Newell, Wilmon, Agr. Exp. Sta., Gainesville, Fla.
'15. Newman, Geo. B., 142 S. Frasier St., State College, Pa.
'28. Nichol, A. A., Agr. Exp. Sta., Univ. of Ariz., Tucson, Ariz.
'22. Noble, W. B., Box 495, U. S. Ent. Labr., W. Lafayette, Ind.
'17. *Notman, Howard, 136 Joralemon St., Brooklyn, N. Y. *Coleopt.*

'28. O'Dell, J. H., P. O. Box 1857, Phoenix, Ariz.
'08. O'KANE, WALTER C., Durham, N. H. (F. '25).
'16. Olsen, Chris E., Amer. Mus. Nat. History, New York, N. Y. *Homopt.*
Ch. OSBORN, HERBERT, Ohio State Univ., Columbus, Ohio. (F. '07; H. F. '28). *Homop.*
'08. Osborn, H. T., Central Aquirre Porto Rico. *Sugar Cane Ins.*
Ch. OSBURN, RAYMOND C., Dept. Ent., Ohio State Univ., Columbus, Ohio. (F. '17).
'26. Osburn, Reginald H., Ont. Agr. Coll., Guelph, Ont., Can.
'20. Otanes, Fausting Q., Bur. of Agr., Manila, P. I.
'17. Ouellet, Joseph C., Deaf and Dumb Inst., 7400 Boul. St., Laurent, Montreal, Quebec, Canada.

'27. Pack, H. J., Agr. Exp. Sta., Logan, Utah.
'15. Packard, Clyde M., Box 495, W. Lafayette, Ind.
'18. Painter, H. R., U. S. Ent. Labr., Box 495, W. Lafayette, Ind. *Orthop.*
'19. Painter, Reginald H., Ent. Dept., State Coll. Agr., Manhattan, Kans. *Dipt., Bombyl.*
'23. Pallister, John C., Mus. Nat. Hist., 2717 Euclid Ave., Cleveland, Ohio. *Coleopt.*
'28. Palmer, Miriam A., Dept. Ent., Agr. Coll., Ft. Collins, Colo. *Coccinellidæ, Aphididæ.*
'27. Park, Orlando, 5006 Dorchester Ave., Chicago, Ill. *Lampyridæ.*
'24. Parker, Donald L., 10 Pearl St., Melrose Highlands, Mass.
'26. Parker, H. L., Le Mont Fenouillet, Hyeres, Var, France. *Behavior.*
'18. Parker, J. B., 1217 Lawrence St., N. E., Washington, D. C. *Bembicidæ.*
'24. Parker, Ralph L., Dept. Ent., Agr. Coll., Manhattan, Kans. *Apiculture.*
'16. Parker, R. R., U. S. P. H. S., Hamilton, Mont. *Sarcophagidæ, Acarina.*
'16. Parks, H. B., R. R. E., Box 368, San Antonio, Texas.
'18. Parks, T. H., Dept. Ent., Ohio State Univ., Columbus, Ohio.
'24. Parman, D. C., Box 509, Uvalde, Texas. *Muscoidea, Anoplura, Mallophaga.*
Ch. PARROTT, P. J., Agr. Exp. Sta., Geneva, N. Y. (F. '14).
'12. Parshley, H. M., Smith Coll., Northampton, Mass. *Heteroptera.*
Ch. *PATCH, EDITH M., Exp. Sta., Orono, Me. (F. '14). *Aphididæ.*
'26. Patch, Lawrence H., Box 976, Sandusky, Ohio.
'27. Pate, V. S. L., 5703 N. Sixth St., Phila., Pa.
Ch. Paxson, Owen S., Radnor, Delaware Co., Pa.
'23. Payne, Nellie M., Zool. Labr., Univ. of Penna., Phila., Penna. *Trichopt.*
'19. Peairs, L. M., Morgantown, W. Va. *Mallophaga, Thysanoptera.*
'24. Peltier, Paul X., Dept. Ent., Univ. of Maryland, College Park, Md.
†'11. Peterson, Alvah, Bur. of Ent., Moorestown, N. J. *Dipt.*
'07. Petrunkevitch, Alex., Zool. Labr., Yale, New Haven, Conn. *Arachnida.*
Ch. Pettitt, R. H., Agr. Exp. Sta., East Lansing, Mich. *Coccidæ.*
'21. Phillips, E. F., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Apiculture.*
'12. Phillips, W. J., U. S. Ent. Labr., Box 592, Charlottsville, Va. *Harmolita.*
'26. Phipps, Clarence R., Agr. Exp. Sta., Orono, Me. *Noctuidæ.*

Ch. Pierce, W. Dwight, Vict. Milling Co., Victorias, Occid. Negros, P. I.
'24. Plath, O. E., 688 Boyleston St., Boston, Mass. *Bremidæ.*
'26. Polivka, Joseph B., Exp. Sta., Oak Harbor, Ohio.
'26. Pomeroy, Fred E., Bates Coll., Lewiston, Me.
'13. Poos, Fred W., Bur. Ent., Dept., Agr., Washington, D. C.
'18. Pope, Thomas E. B., Public Mus., Milwaukee, Wis.
'23. Porter, Bennett A., 10 W. Sycamore St., Vincennes, Ind.
'27. Potts, S. F., Jr., 17 E. Highland Ave., Melrose Highlands, Mass. *Parasitism.*
'26. Powell, Eugene F., Univ. Hall, Lincoln, Neb. *Chrysomelidæ.*
Ch. Powell, P. B., Clinton, N. Y.
'15. Powers, Edwin B., Dept. Zool., Univ. of Tenn., Knoxville, Tenn.
'16. Price, W. A., Dept. Ent., Purdue Univ., Lafayette, Ind.
'16. Psota, Frank J., 4046 W. Twenty-sixth St., Chicago, Ill. *Cetonidæ.*

Ch. QUAINTANCE, A. L., Bur. Ent., Dept. Agr., Washington, D. C. (F. '14). *Aleyrodidæ.*

Ch. Ramsden, Chas. T., P. O. Box 146, Guantanamo, Cuba. *Lepidopt.*
'23. Randolph, Abraham M., Casilla I, Validivia, Chile, S. Amer.
'13. RAU, PHIL, 549 E. Argonne Drive, Kirkwood, Mo. (F. '28). *Hymenopt., Behavior.*
'23. Readio, Philip A., 1203 O'Read Ave., Lawrence, Kans. *Heteropt.*
'23. Reed, Wm. D., 712 Elizabeth St., Fresno, Calif. *Dipt.*
'22. Reed, W. V., Dept. Agr., Raleigh, N. Car.
'19. Reeher, Max, Forest Grove, Ore.
'23. Reeves, Jos. A., Box 549, Sanford, Fla. *Chrysomelidæ.*
'08. Regan, W. S., Box 853, Yakima, Wash.
Ch. REHN, JAMES A. G., Acad. Nat. Sci., Logan Sq., Phila., Pa. (F. '14). *Orthopt.*
'21. Remy, T. P., Box 13, Port Arthur, Texas. *Culicidæ.*
'14. Richardson, Chas. H., Bur. Ent., Dept. Agr., Washington, D. C. *Physiol.*
'22. Ries, Donald T., 401 Thurston Ave., Ithaca, N. Y. *Siricidæ.*
'28. Rifenburgh, S. A., 246 Marstellar St., W. Lafayette, Ind.
Ch. Riley, C. F. Curtis, Univ. of Manitoba, Winnipeg, Manitoba, Canada.
'28. Riley, H. K., Purdue Univ., Agr. Exp. Sta., Lafayette, Ind., *Dipt.*
Ch. RILEY, W. A., Univ. Minn., Minneapolis, Minn. (F. '14). *Parasitology.*
'14. Ris, F., Rheinau, Kanton Zurich, Switzerland. *Odonata.*
'26. Rivnay, Ezekiel, 2050 Harrison Ave., Bronx, N. Y. *Rhipiphoridæ.*
'15. Robinson, J. M., Dept. Zool., Auburn, Ala. *Coccidæ, Coleopt.*
'27. Robinson, Wm., Dept. Ent., Univ. Farm, St. Paul, Minn. *Physiol.*
'13. Rockwood, L. P., Forest Grove, Ore.
'15. Rogers, J. Speed, Dept. Biol., Univ. Fla., Gainesville, Fla. *Tipuloidea.*
'23. Rogers, Leslie, Box 4036, Univ. Tenn., Knoxville, Tenn. *Rhopalocera, Coleopt.*
'28. Rohwer, S. A., Bur. Ent., Dept. Agr., Washington, D. C. *Hymenop.*
'28. Roney, James N., Div. Ent., College Station, Texas.
'22. Root, Francis M., School of Hygiene, 615 N. Wolfe St., Baltimore, Md. *Culicidæ, Muscidæ.*
'14. Rosenfeld, Arthur H., 1005 N. O. Bank Bldg., New Orleans, La.
'26. Rosewall, O. W., La. State Univ., Baton Rouge, La. *Coleop.*
'24. Ross, Charles F., 86 Summer St., Lee, Mass.
'12. Ross, Wm. A., Ent. Labr., Vineland Station, Ont., Canada. *Aphididæ.*
'14. Ruckes, Herbert, 167–11 33rd St., P. O. Sta. A, Flushing, L. I., N. Y. *Morphol.*
Ch. Ruggles, A. G., Univ. Farm, St. Paul, Minn.
Ch. Rumsey, W. E., 415 Park St., Morgantown, W. Va.

'23. Salman, Kenneth A., 82 Pleasant St., Amherst, Mass. *Cerambycidæ.*
Ch. SANDERS, J. G., 1808 Finance Bldg., Care Sun Oil Co., Phila., Pa. (F. '20).
Ch. Sasscer, E. R., Fed. Hort. Board, Dept. Agr., Washington, D. C.
'07. Satterthwait, Alfred F., Ent. Lab., 527 Ivanhoe Pl., Webster Groves, Mo. *Calendra.*

'24. Sazama, Robt. F., 2 E. Locust St., Vincennes, Ind.
'26. Schear, E. W. E., 107 W. Park St., Westerville, Ohio.
'19. Schmieder, Rudolph G., 4351 Pechin St., Phila., Pa.
Ch. Schoene, W. J., Agr. Exp. Sta., Blacksburg, Va.
'27. Schwardt, Herbert H., Box 173, Bentonville, Ark.
'28. Schwarz, Ernest, Game and Fish Dept., Jefferson City, Mo.
Ch. SCHWARZ, EUGENE A., U. S. Nat. Mus., Washington, D. C. (F. '07; H. F. '14).
'26. Schwarz, Eugene K. W., 40 W. 84th St., Apt. 8, A, New York City, N. Y.
'27. Schwarz, Herbert F., Am. Mus. N. H., 77th St. and Cent. Park W., New York City, N. Y.
'28. Scotland, Minnie B., 42 Continental Ave., Cohoes, N. Y.
'26. Scullen, Herman A., 2003 B. St., Corvallis, Ore. *Hymenop.*
'23. Seamans, Howard L., Ent. Lab., Lethbridge, Alberta, Canada. *Dipt., Anthomyiidæ, Muscidæ.*
'24. Seeley, Ralph M., 21 Avondale Rd., Avondale Estates, Ga. *Coccidæ.*
'22. Sellers, Wendell F., 51 Clifford St., Melrose Highlands, Mass.
'08. Severin, H. C., State College, Brookings, S. Dak. *Orthopt., Hemip.*
'07. Shafer, Geo. D., 321 Melville Ave., Palo Alto, Calif.
'19. *Shannon, Raymond C., U. S. Nat. Mus., Washington, D. C. *Dipt.*
'28. Sheaffer, F. E., 4257 Winthrop St., Indianapolis, Ind.
Ch. SHELFORD, VICTOR E., Vivarium Bldg., Champaign, Ill. (F. '20). *Ecology.*
'22. Shepard, Harold H., Box 156 Hyattsville, Md. *Hesperiidæ.*
'17. Sherman, Franklin, Div. Ent. and Zool., Clemson Coll., S. Car.
'11. Sherman, John D., Jr., 132 Primrose Av., Mt. Vernon, N. Y. *Coleop.*
'28. Shiller, Ivan, 309 Aztec Bldg., San Antonio, Texas.
'23. Shotwell, Robert L., Box 1094, Billings, Mont. *Orthop.*
Ch. Shull, A. Franklin, 431 Highland Rd., Ann Arbor, Mich. *Aphididæ.*
'19. Sibley, Chas. K., John Burroughs School, Clayton, Mo. *Trichop.*
'15. SILVESTRI, FILLIPPO R., Scuola Superiore d'Agricoltura, Portici, Italy. (F. '20). *Thysanura, Protura, Termites, Myriapods.*
'26. Simons, Mrs. Carrie L., 4021 Almeda Drive, San Diego, Calif.
'28. Smith, Chas. W., Corn Borer Lab., 267 Victoria Av., Chatham, Ont., Canada. *Tachinidæ.*
'27. Smith, F. F., Greenhouse Insect Lab., Willow Grove, Pa. *Aphididæ.*
Ch. Smith, James A., 414 E. Broad St., Westfield, N. J.
'19. Smith, Marion R., State Plant Board, A. & M. College, Miss. *Ants.*
'14. Smith, Roger C., Service Technique, Port au prince, Haiti. *Neuroptera.*
'14. Smulyan, Marcus T., Bur. Ent., Melrose Highlands, Mass. *Tenthredinidæ.*
Ch. Smyth, Ellison A., Jr., R. No. 2, Box 63, Salem, Va. *Papilionidæ, Sphingidæ.*
'18. Snapp, Oliver I., U. S. Bur. Ent., Fort Valley, Ga. *Rhynchophora.*
'24. SNODGRASS, R. E., 3706 13th St., N. W., Wash., D. C. (F. 28). *Morphology.*
'22. Snyder, Thomas E., U. S. Bur. Ent., Washington, D. C. *Isoptera.*
'27. Sorenson, Charles J., Agric. Exp. Station, Logan, Utah.
'26. Spaulding, Miss Nina G., Jaffrey, N. H.
'14. *Spencer, G. J., Univ. British Columbia, Vancouver, B. C. *Trypetidæ.*
'19. Spencer, Herbert, Dept. Ent., La. Exp. Sta., Baton Rouge, La. *Parasitic Hymenopt.*
'21. Spencer, Robert D., 607 Centre St., Ashland, Pa. *Dipt.*
Ch. Spooner, Charles S., 1436 Seventh St., Charleston, Ill. *Hemipt.*
'22. Spuler, Anthony, 611 Michigan Ave., Pullman, Wash. *Dipt., Borboridæ.*
'26. Squire, Eben H. P., 2 William St., White Plains, N. Y.
'10. Stafford, E. W., A. & M. College, Miss. *Acalyptrate Muscoids.*
'19. Stahl, C. F., Trop. Plant Res. Foundation, Central Baragua, Baragua, Cuba.
'19. Stear, J. R., 245 Fifth Ave., Chambersburg, Pa. *Miridæ.*
'17. Stearns, Louis A., Exp. Sta. Lab., 713 Center St., Ironton, Ohio. *Cercopidæ, Cicadellidæ.*
'23. Steele, Brandt F., 811 E. Drive, Woodruff Pl., Indianapolis, Ind. *Coleopt.*
'27. Steiner, L. F., Dept. Ent., Purdue Exp. Sta., Lafayette, Ind.
'26. Stephenson, Lyle, 35 W. 52nd St., Kansas City, Mo.
'21. Stevens, O. A., Agr. Coll., North Dakota. *Bees, Wasps.*

'25. Stewart, Kenneth E., 322 Frank St., Apt. 7, Ottawa, Canada.
'17. Stickney, Fenner S., 1119 Fulton St., Palo Alto, Calif. *Coccidæ.*
'15. Stiles, Chas. F., Box 37, Stillwater, Oklahoma.
'26. Still, Geo. W., 404 W. Nevada St., Urbana, Ill.
'22. Stirrett, Geo. M., Corn Borer Lab., Chatham, Ont., Canada. *Halticini, Trichop.*
'28. Stone, Alan, Forest Home, Ithaca, N. Y. *Tabanidæ.*
'13. Stoner, Dayton, 603 S. Summit St., Iowa City, Ia. *Pentatomoidea.*
'28. Street, T. M., N. Dak. School Forestry, Bottineau, N. Dakota.
'12. Strickland, E. H., The University, Edmonton, Alberta, Canada.
'26. Strohecker, H. F., 123 Culver St., Macon, Ga.
'28. Sullivan, K. C., Dept. Ent., Univ. of Missouri, Columbia, Mo. *Chironomidæ, Culicidæ.*
'08. Summers, John N., Room 303, 408 Atlantic Ave., Boston, Mass. *Coccidæ.*
'20. SWAINE, J. M., Dept. Agr., Ottawa, Can. (F. '21). *Forest Insects.*
'21. Sweet, Georgeana, The Univ. Vet. Res. Inst., Story St., Parkville, Melbourne, Australia.
'23. Sweetman, Harvey L., Univ. of Wyoming, Agr. Exp. Sta., Laramie, Wyo. *Ecol.*
'20. Swezey, Otto H., 2048 Lanihuli Drive, Honolulu, T. H. *Lepidopt., Coleopt.*
'22. Swingle, Homer S., Ent. Lab., Fort Valley, Ga. *Physiol.*

'21. Takahashi, Ryoichi, Dept. Agr., Gov. Res. Inst., Taihoku, Formosa, Japan. *Aphididæ, Coccidæ.*
'28. Tanner, V. M., Brigham Young Univ., Provo, Utah.
Ch. Tanquary, M. C., Box 361, Fargo, N. D. *Formicidæ.*
'22. Taylor, Leland H., Dept. Zool., W. Va. Univ., Morgantown, W. Va. *Chrysididæ.*
'21. Thomas, Chas. A., State Agr. Coll. Lab., Bustleton, Pa. *Aphididæ, Hymenopt. parasites.*
'15. Thomas, F. L., State Entomologist, College Station, Texas.
'09. Thomas, W. A., Bur. Ent., Chadbourn, N. C.
'10. THOMPSON, W. R., Farnham House Laboratory, Farnham Royal Bucks, England. (F. '27). *Tachinidæ.*
'22. Tietz, Harrison M., Dept. Zool., State Coll., State College, Pa. *Lepidopt.*
'20. Tillyard, R. J., 314 Albert St., Melbourne, Australia. *Fossil Insects.*
'11. Timberlake, P. H., Citrus Exp. Sta., Riverside, Calif. *Encyrtidæ.*
'23. Tissot, Archie N., Exp. Sta. Gainsville, Fla. *Aphididæ.*
Ch. Titus, E. G., 1228 Bryan Av., Salt Lake City, Utah. *Apidae, Megachilidæ.*
'27. Todd, Frank E., Bur. of Plant Quarantine, Dept. Agr., Sacramento, Calif. *Hymenop.*
'21. Townsend, M. T., Piseco, N. Y.
'24. Turner, Paul A., 355 Duval St., Germantown, Phila., Pa. *Odonata.*
'08. Turner, Wm. F., 430 Washington, Ave., Macon, Ga. *Elateridæ.*

'20. Uichanco, L. B., Coll. Agr., Los Banos, Laguna, P. I. *Thysanopt, Psyllidæ, Aphididæ.*
'17. Urich, F. W., 107 Frederick St., Port-of-Spain, Trinidad, British W. I.

'26. Valentine, Joseph Manson, Dept. Biol., West. Res. Univ., Cleveland, Ohio.
'22. Vance, Arlo M., 10 Court St., Arlington, Mass.
Ch. Van Dine, D. L., Central Baragua, Baragua, Prov. of Camaguey, Cuba.
Ch. VAN DUZEE, E. P., Cal. Ac. Sci., Golden Gate Pk., San Francisco, Cal. (F. '12). *Hemipt.*
'17. Van Duzee, Millard C., 12 Abbotsford Pl., Buffalo, N. Y. *Dolichopodidæ.*
Ch. VAN DYKE, EDWIN C., Univ. Cal., Berkeley, Cal. (F. '17). *Coleopt.*
'23. Vellard, Jehan A., Inst. Vital Brazil, C. P. 28, Nictheroy, Estado do Rio, Brazil. *Arach.*
Ch. Vickery, R. A., 52 Union St., Bay Shore, N. Y.
'13. Vorheis, Chas. T., Univ. Station, Tucson, Arizona.
'28. Voris, Ralph, 222 E. Seventh St., Bloomington, Ind. *Coleop.*

'15. Wade, Jos. S., Bur. Ent., Washington, D. C. *Coleopt.*
'21. Wadley, F. M., Dept. Ent., Univ. Farm, St. Paul, Minn. *Aphididæ, Hemipt.*
'18. Wainwright, Colbran J., 172 Hamstead Rd., Handsworth, Birmingham, England. *Tachinidæ.*
'22. Wakeland, Claude, Ent. Fld. Sta., Parma, Idaho. *Eleodiini, Tenebrionidæ.*
'22. Walkden, Herbert H., 126 S. Minneapolis Ave., Wichita, Kans.
'10. WALKER, E. M., Univ. Toronto, Toronto, Can. (F. '14). *Odonata, Orthopt.*
'26. Walker, Fred H., P. O. Box 456, Salem, Mass. *Behavior.*
'23. Walker, Fred W., Box 92, Monticello, Fla. *Orthopt., Dermapt.*
'23. Wallace, Hugh E., Box 1100, Twin Falls, Idaho.
'11. Wallis, J. B., 211 Waterloo St., Winnipeg, Man., Can. *Coleopt.*
'26. Walton, L. B., Kenyon College, Gambier, Ohio. *Endomychidæ, Thysanura.*
'17. Walton, W. R., Room 5, Bur. Ent., Washington, D. C.
'13. Watson, J. R., Agr. Exp. Sta., Gainesville, Fla. *Thysanopt.*
'26. Watson, S. A., 220 Fife Ave., Wilmington, Ohio. *Miridæ.*
'16. Webber, Ray T., 17 E. Highland Av., Melrose Highlands, Mass. *Dipt.*
Ch. Webster, R. L., Agr. Exp. Sta., Pullman, Wash.
'28. Weed, Alfred, 625 Mendota Court, Madison, Wis.
Ch. WEED, CLARENCE M., State Normal School, Lowell, Mass. (F. '25).
'26. Weeks, Andrew G., 15 State St., Boston, Mass. *Lepidop.*
'17. Weese, A. O., Univ. of Okla., Norman, Okla. *Ecology.*
'18. Wehrle, L. P., Renwick Heights, Ithaca, N. Y.
'17. Weigel, Chas., A., U. S. Bur. Ent., Wash, D. C. *Greenhouse Ins.*
'13. Weiss, Harry B., 19 N. Seventh Ave., Highland Pk., New Brunswick, N. J. *Ecol.*
'12. WELCH, P. S., Univ. Mich., Ann Arbor, Mich. (F. '20). *Aquatic Ins.*
'07. Weld, Lewis H., East Falls Church, Va. *Cynipidæ.*
'22. Wellhouse, W. H., Dept. Zool. and Ent., State Coll., Ames, Iowa.
'19. Wells, B. W., State College, Raleigh, N. C. *Insect Galls.*
'12. Wells, M. M., 761 E. 69th Place, Chicago, Ill.
'21. West, Luther S., Dept. Biol., Battle Creek Coll., Battle Creek, Mich. *Dipt.*
'18. Whedon, Arthur D., 1145 Third St. N., Fargo, N. D. *Odonata.*
'26. Wheeler, Ellsworth H., Ent. Dept., Cornell Univ., Ithaca, N. Y.
'22. Wheeler, Geo. C., Dept. Biol., Univ. N. D., Grand Forks, N. D. *Parasitic Hymenopt., Formicidæ.*
Ch. WHEELER, W. M., Bussey Institution, Boston, 30, Mass. (F. 07). *Formicidæ.*
'26. Whelan, Don B., Univ. Nebr., Lincoln, Nebr.
'22. Whitehead, Fred E., Zool. Dept., Idaho Univ., Moscow, Idaho.
Ch. WICKHAM, H. F., 911 E. Iowa Av., Iowa City, Iowa. (F. '14). *Coleopt.*
'24. Wilcox, Joseph, 31 N. 26th St., Corvallis, Ore. *Dipt.*
'17. Wild, William, 249 Walnut St., E. Aurora, N. Y. *Microlepidopt.*
'21. Wiley, Mrs. Grace Olive, 2291 Doswell Av., St. Paul, Minn. *Aq. Hemipt.*
'27. Willard, H. F., P. O. Box 340, Honolulu, T. H.
'14. WILLIAMS, C. B., Amani Res. Inst., Tanga, Tanganyika, Ter. Africa. (F. '20). *Thysanopt.*
'26. Williams, John E., 309 Wilder Bldg., Rochester, N. Y.
'14. Williams, R. C., Jr., 4537 Pine St., Phila., Pa. *Hesperidæ.*
Ch. WILLIAMSON, E. B., Bluffton, Ind. (F. '14). *Odonata.*
'11. Williamson, Warren, R. F. D. No. 5, Galesburg, Ill.
'23. Willis, Warren J., Room 407, 30 E. 42nd St., New York, N. Y. *Aq. Ins.*
'23. Wilson, Cecil C., 600 26th St., Sacramento, Cal. *Orthop.*
'26. Wilson, Francis H., Univ. Richmond, Richmond, Va. *Mallophaga.*
Ch. Wilson, H. F., Univ. Wisconsin, Madison, Wis. *Aphididæ.*
Ch. *Wirtner, M., St. Bonifacius, Cambria Co., Pa. *Hemipt.*
'28. Wisecup, C. B., R. R. 1, Manhattan, Kans.
Ch. Woglum, R. S., Cal. Fruit Growers Exchange, Los Angeles, Cal.
'08. Wolcott, R. H., Univ. Nebraska, Lincoln, Nebr. *Hydracarina.*
'26. Woo, Fo Ching, Box 23, Univ. Sta., Urbana, Ill.
'14. Wood, W. B., Dept. Agr., Fed. Hort. Bd., Washington, D. C.

'26. Woodruff, Lawrence C., U. S. Ent. Lab., Charlottsville, Va.
'13. Woods, Wm. C., Kent School, Kent, Conn. *Chrysomelidæ.*
'17. Woodworth, C. W., Prof. of Ent., Univ. Calif., Berkeley, Calif.
'17. Woodworth, H. E., Calif. Spray Chemical Co., Watsonville, Calif.
'22. Worthley, Harlan N., Exp. Sta., State College, Pa. *Tachinidæ, Pepsini.*

Ch. Yothers, W. W., Box 491, Orlando, Fla.
'25. Young, Martin T., Box 165, Tallulah, La.
'17. Yuasa, Hachiro, Ent. Lab., Imp. Univ., Kyoto, Japan. *Physiol.*

'28. Zebrowski, G., Villa Nova Coll., Villa Nova, Pa. *Acarina, Hemipt.*
'21. Zerny, Hans, Burgring F., Wien 1, Austria. *Heterocera.*
'07. Zetek, James, Drawer C, Ancon, Canal Zone. *Isoptera, Coccidæ.*
'27. Zimmer, Lawrence A., Corn Borer Lab., Oak Harbor, Ohio. *Hemip., Coleop.*